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Cover: Leatherback Turtle, *Dermochelys coriacea*, on dock at Fisherman's Market, St. John's, Newfoundland, after getting entangled in fishing gear, and shortly before release. Photograph courtesy of Jon Lien. See Goff and Lien pp. 1-5.

The Canadian Field-Naturalist

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Atlantic Leatherback Turtles, *Dermochelys coriacea*, in Cold Water Off Newfoundland and Labrador

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Goff, Gregory P., and Jon Lien. 1988. Atlantic Leatherback Turtles, *Dermochelys coriacea*, in cold water off Newfoundland and Labrador. *Canadian Field-Naturalist* 102(1): 1-5.

Encounters with 20 Leatherback Turtles (*Dermochelys coriacea*) in waters off Newfoundland and Labrador between 1976 and 1985, primarily through incidental catches in inshore fishing gear, are reported. Leatherback Turtles were found in July-September and were associated with seasonally high water temperatures. Healthy animals which occur in coastal Newfoundland waters are probably not strays, and encounters to date may indicate the turtles' regular use of this habitat.

Key Words: Leatherback Turtle, *Dermochelys coriacea*, incidental fishery catches, Newfoundland.

The marine Leatherback Turtle, *Dermochelys coriacea*, is the largest known extant reptile, and reaches weights in excess of 680 kg (Rhodin et al. 1981). It is a cosmopolitan species that enters Canadian waters off both the Atlantic and Pacific coasts.

The Leatherback Turtle is suitably adapted to cold water. Friar et al. (1972) recorded a 25.5°C body temperature for a captive Leatherback Turtle in 7.5°C seawater. They possess vascular counter-current heat exchangers in their flippers (Greer et al. 1973), and have thick subcutaneous insulation. Standora et al. (1984) measured this species' endothermic ability to respond to a drop in ambient temperature by metabolically increasing its heat production.

The Leatherback Turtles' intrusions into cold water are seasonal (Pritchard 1971). Bleakney (1965) compiled records of 88 Leatherback Turtles in New England and Nova Scotian waters from June to October between 1899 and 1964 and concluded that these northward travels were made by healthy turtles of various ages and sexes in order to feed on large northern jellyfish (*Cyanea capillata arctica*). Based on preferential feeding by leatherbacks on this species, Lazelle (1980) argued

that the high medusan-producing waters off New England are critical leatherback habitat.

Bleakney (1965) recorded only two Leatherback Turtles in the cold northeastern coastal waters around Newfoundland and Labrador. Steele (1972) reported a specimen in Conception Bay, Newfoundland. Threlfall (1978) reported a single animal found near Nain, Labrador.

Despite recent increases in its world population estimates, the leatherback is still considered an endangered species (Pritchard 1982). Many adults are slaughtered annually on nesting beaches and egg collection is still practised. Once considered secure away from nesting beaches, this pelagic species now suffers some commercial fisheries-related mortality in Pacific (Balazs 1982) and Atlantic (Lien 1980) net fisheries.

This paper reports encounters with leatherbacks in Newfoundland coastal waters from 1976 to 1985 and ocean temperatures in the vicinity of the sighted turtles.

Methods

In 1979 a toll-free phone line was initiated by which fishermen could report whales and sharks entrapped in their fishing gear. This service was

widely advertised throughout Newfoundland and Labrador and has been described in detail elsewhere (Lien 1980). As they became more familiar with the service, fishermen began to report unusual fish, seals, squid and turtles caught in their nets, as well as abnormal water conditions and fishery problems (Lien et al. 1985).

While this method of reporting is frequently used, it does depend on fishermen to volunteer information. Under-reporting of whale and shark entrapments varied from 25% in the first several years to about 10% in recent years (Lien et al. 1985). Reports of 'unusual' catches apart from whales and sharks were not common in 1979-1980. They have increased since that time. There is no way of knowing the likelihood that sightings or catches of turtles would be reported. The Leatherback Turtles which are reported are therefore a minimum estimate of the actual numbers which have been encountered around the Newfoundland coast.

Prior to establishment of the phone reporting system, occasional reports of Leatherback Turtles were given to field officers of the Department of Fisheries and Oceans or Memorial University of Newfoundland.

In some instances of a reported turtle, an observer was sent to the site to verify the catch and

the species. Alternately, photographs of entrapped specimens were often available. When a catch was reported by a vessel at sea, identity was determined by radio conversation. Specimens of recently dead turtles were obtained when possible for measurement and dissection.

Ocean temperatures in the vicinity of encountered turtles were approximated using data obtained by the long-term temperature monitoring program of the Department of Fisheries and Oceans (Dobson 1982, 1983, 1984; Dobson et al. 1985). This monitoring program uses Ryan Model J thermographs deployed at a 5 to 10 m depth in numerous sites around the Newfoundland coastline. Temperatures at the thermograph located nearest an encountered turtle are presented for the date of the encounter. Maximum temperatures for the month and season of the encounter were also compiled.

Examination of several dead specimens provided morphometric measurements to indicate the animals' size.

Results

Locations of 20 Leatherback Turtles encountered between 1976 and 1985 in northwest Atlantic waters near Newfoundland and water temperatures on the encounter date are presented in Table 1. Locations of

TABLE 1. The sightings and incidental catches of Leatherback Turtles in Newfoundland (1976-1985).

Date	Location	Water Temp (°C)	Capture Method	Condition at release
21 September 1976	Western Bay, C.B.	—	salmon net	alive
3 October 1976	Lourdes	—	herring net	alive
6 July 1977	Trepassey	—	gillnet	alive
2 September 1981	Petty Harbor	15	trawl line	alive
13 September 1981	St. Bernard's, F.B.	14	free swimming	alive
28 September 1981	Bauline South	15	gillnet	alive
21 October 1981	York Harbor	—	found dead	dead
15 August 1982	Port aux Basque	—	gillnet	dead
20 August 1982	Bauline, C.B.	11	gillnet	alive
25 July 1983	St. Brides, P.B.	14	gillnet	alive
14 August 1983	Lumsden	13	gillnet	dead
20 March 1984	Sunnyside, T.B.	0	free swimming	alive
13 August 1984	Jerseyside, P.B.	14	trawl line	dead
26 August 1984	Southern Hbr., P.B.	14	found dead	dead
4 August 1985	Flatrock	12	free swimming	dead
5 August 1985	Burin	9	gillnet	alive
5 August 1985	Flatrock	12	free swimming	alive
10 August 1985	Bonavista, B.B.	10	gillnet	alive
14 August 1985	Harbour Grace, C.B.	11	crab pot line	dead
23 September 1985	Happy Adventure, B.B.	12	gillnet	alive

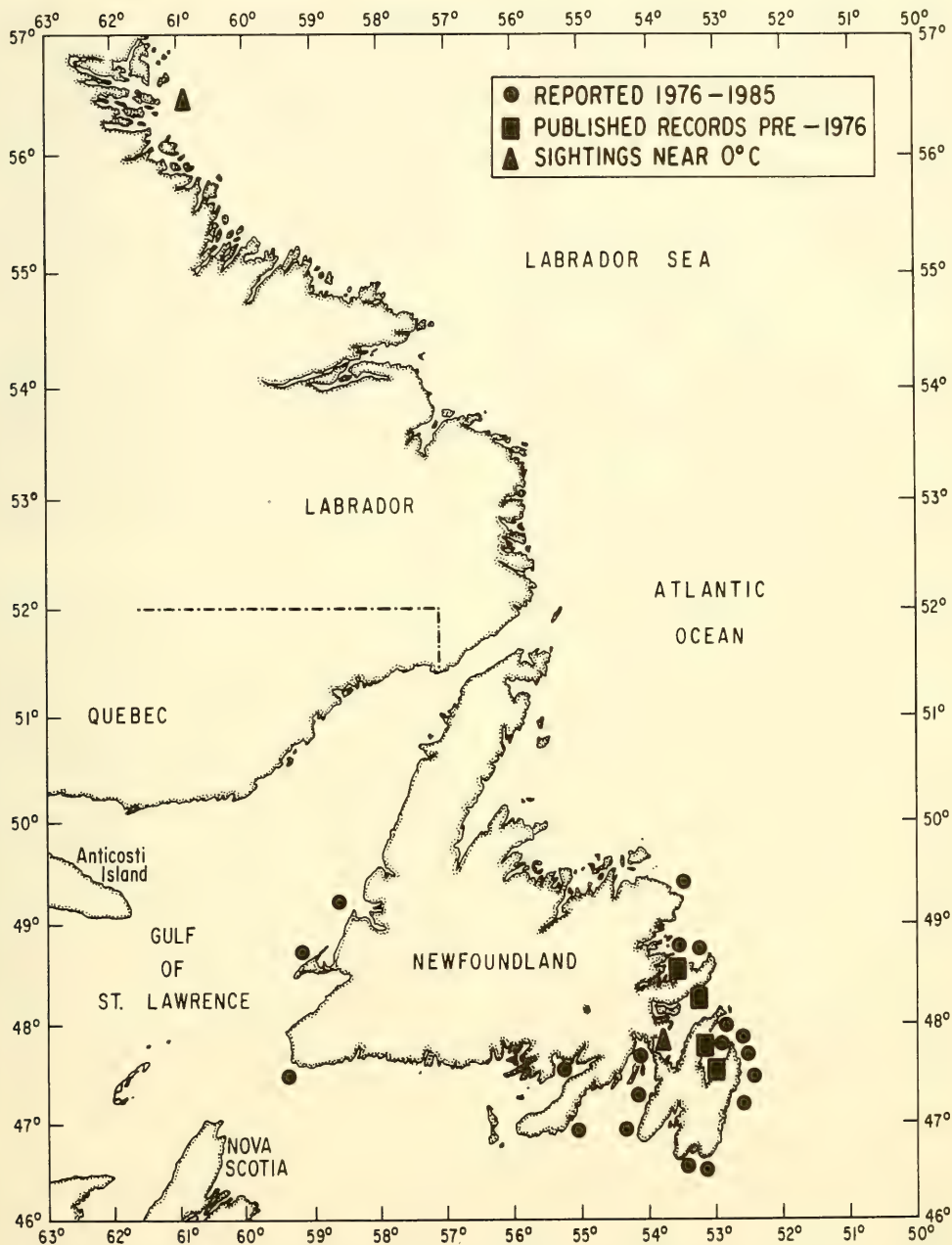


FIGURE 1. Locations of encounters with Leatherback Turtles in Newfoundland waters. Reports prior to 1976 are from Squires (1954), Steele (1972), Threlfall (1978), and Bleakney (1965).

these encounters, along with locations of leatherbacks previously reported in waters off Newfoundland, are presented in Figure 1.

Of 20 Leatherback Turtles encountered, 14 were entangled in fishing gear (70%), 4 were observed swimming freely (20%), and 2 were reported dead

TABLE 2. Summary of reported encounters with Leatherback Turtles by Newfoundland fishermen 1976-1985.

Condition	Total N	N Released	Mortality
Entangled in fishing gear	14	10	4
a. gillnets	11	9	2
b. trawl or crab pot lines	3	1	2
Free-swimming	4	3	1
Found dead	2	—	2
Totals	20	13	7

(10%). Ten of the turtles entangled in fishing gear were released alive (70%); the remainder were found dead or were killed in the process of being removed from the gear. One free-swimming turtle was shot (Table 2).

August and September were the months when turtle encounters were most likely. Ocean temperatures on the day Leatherback Turtles were encountered (mean $\pm$ S.D. = $12.6 \pm 1.9^{\circ}\text{C}$) were on average within 2.2 degrees C of the monthly maximum temperature (mean $14.7 \pm 1.6^{\circ}\text{C}$) at that location (Table 1). Average annual maximum temperature recorded $14.4 \pm 1.3^{\circ}\text{C}$.

One notable exception to this association with seasonal high water temperatures was one turtle reported in Trinity Bay on 20 March 1984. It was alive and observed by fishermen throughout an entire day swimming in open water leads among ice where water temperatures was approximately 0°C . It is not known if this animal survived.

The sizes of turtles in Newfoundland waters are indicated by the measurements in Table 3. No tags were found on any animals examined.

Discussion

Recent records of Leatherback Turtles in waters off Newfoundland confirm their regular and seasonal occurrence in this area. Most of the turtles encountered are reported in the eastern portion of

the province where the amount of inshore fishing activity is highest. The increase in reports in recent years reflects increased use of the toll-free phone system and does not represent any real increase in catch per fishing effort. Still, the number of turtles reported very likely represents a minimal proportion of the turtles encountered and an even smaller proportion of the actual number of turtles present in these waters.

Ocean circulation on the Newfoundland continental shelf is such that a large proportion of the turtles reported here came under the influence of the Labrador Current (Petrie and Anderson 1983), a southward-flowing mass of cold arctic water. The average ocean temperature near the locations of turtle encounters between 1981 and 1985 was 12.6°C , near the warmest ocean temperatures (mean = 14.4°C) recorded in those areas for the year. It is likely that Leatherback Turtles move northward in warm Gulf Stream water and only venture into the Labrador current water at inshore Newfoundland when it is very near yearly maximum temperatures.

Examinations of dead specimens and the reported behaviour of free-swimming turtles confirm that these animals north of 48 degrees latitude are healthy. The presence of 6-7 cm of adipose tissue under the carapace indicates their good condition and may represent a further

TABLE 3. Sex and measurements (in cm) of four Leatherback Turtles from waters off Newfoundland.

Measure	Specimen			
	Oct. 1981	Aug. 1983	Aug. 1985	Aug. 1985
Sex	—	F	F	F
Carapace length over the curve	165	135	146	140
Carapace width — curved maximum	120	—	110	84
Margins of left front flipper (anterior/posterior)	123/92	—/—	100/75	94/73

adaptation for periodic intrusion into cold environments.

The destinations and routes of the turtles encountered in northwestern Atlantic waters are not established. It is unlikely that they are strays because of their excellent condition. Carapace lengths, which range from 135 to 165 cm, suggest these animals are mature (Rhodin 1985), but their eventual breeding sites and the nature of their migratory paths remain open to speculation. They should be considered regular migrants to Newfoundland waters.

The mortality which results from entanglement with fishing gear is fairly low; about 70% of the entangled turtles between 1981 and 1985 were released alive. Two of four entangled turtles perished naturally in the gear; two others were killed. It is possible that the other two turtles found dead were killed in fishing gear. Mortality may have decreased recently through educational efforts which give fishermen encouragement to release live animals (Lien et al. 1985).

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Effects of the Herbicide 2,4,5-T on the Habitat and Abundance of Breeding Birds and Small Mammals of a Conifer Clearcut in Nova Scotia

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Freedman, B., A. M. Poirier, R. Morash, and F. Scott. 1988. Effects of the herbicide 2,4,5-T on the habitat and abundance of breeding birds and small mammals of a conifer clearcut in Nova Scotia. *Canadian Field-Naturalist* 102(1): 6-11.

After the silvicultural herbicide spraying of a conifer clearcut in Nova Scotia, the foliage cover of shrub-sized plants was reduced by an average factor of 41% compared with the pre-spray condition, while during the same period an unsprayed reference plot increased in cover by a factor of 29%. Shrub-sized plants on the sprayed plots were also reduced in stem density (by 31%) and basal area (67%). The total cover of ground vegetation was also reduced on the spray plots (by an average factor of 19%), while on the reference plot it increased by 16%. However, vegetation on the sprayed plots was still abundant, and the habitat changes were not sufficient to cause an important difference in the abundance, species richness, and diversity of breeding birds and small mammals between sprayed and unsprayed plots. The total bird density was 71 pairs/10 ha on the unsprayed clearcut plot, 76 and 77 pr/10 ha on two plots sprayed at the prescribed silvicultural rate of 3 kg 2,4,5-T/ha, and 50 pr/10 ha on a plot sprayed at 6 kg/ha. The abundance of small mammals on these same treatment-plots was 12.8, 14.3, 13.5, and 11.7 per 100 trap-nights.

Key Words: forestry, herbicide, 2,4,5-T, birds, small mammals.

The herbicides that have been commonly used for silvicultural purposes in the 1980s in Canada (i.e. 2,4,5-T, 2,4-D, and glyphosate) have a small toxicity to birds and mammals under operational spray conditions (Way 1969; Kenaga 1975; Morrison and Meslow 1983; Anonymous 1984). However, herbicides have an indirect effect on the habitat of at least some species of wildlife, because they cause changes in: i) the absolute and relative distribution of biomass among plant species; ii) the horizontal and vertical structure of vegetation; and iii) the abundance and quality of the invertebrate and plant food resource (Newton and Norris 1976; Borrecco et al. 1979; Ware 1980; Freedman 1982; Morrison and Meslow 1983, 1984a,b).

Because the impacts of herbicide spraying on the breeding birds and small mammals of regenerating cutovers have seldom been studied (we are aware of no studies in Canada, and only a few from the United States: Beaver 1976; Savidge 1978; Morrison and Meslow 1983), we initiated such work in Nova Scotia. Here we describe the abundance of breeding birds and small mammals, and the changes in their habitat, one year after spraying the phenoxy herbicide 2,4,5-T in a conifer release program.

Methods

The study site is near Stewiacke in central Nova Scotia, at 45°12' N, 63°23' W. The site was

formerly occupied by a conifer stand, but it had been clearcut three years prior to our study, planted with Black and Norway spruce seedlings (see Appendix 1 for all binomials), and required a silvicultural herbicide treatment to reduce the abundance of "weeds" and release the planted and natural conifer regeneration. The clearcut was about 20 hectares in size, roughly rectangular, and appeared uniform in vegetation. It was divided into four rectangular treatment-plots. One plot (4.9 ha) was an unsprayed reference plot, two plots (4.1 and 5.1 ha) were sprayed with 2,4,5-T at the prescribed silvicultural rate (3 kg 2,4,5-T/ha, hereafter abbreviated as "1X"), and one plot was treated at double that rate ("2X"). The plots were sprayed on 11 September 1983 by the Nova Scotia Department of Lands and Forests using a skidder-mounted apparatus (3-nozzle spray cluster, 1700 litre capacity tank with internal stirring mechanism).

Vegetation surveys were done in mid-August of 1983 (prior to spraying) and 1984 (one-year post-spray). Shrub-sized plants were measured in 12 evenly-spaced, 5 m × 5 m permanent quadrats per treatment-plot. For each leaf-bearing stem, the species was noted and the diameter was measured at 25 cm above the ground surface. Calculations were made of stem basal area (SBA; m²/ha) and density (stems/ha).

Ground vegetation was surveyed in $1\text{ m} \times 1\text{ m}$ quadrats located in each corner of the twelve $5\text{ m} \times 5\text{ m}$ quadrats per plot (i.e. 48 ground vegetation quadrats per treatment-plot; however, note that vegetation was not surveyed on the 5.1 ha 1X treatment-plot). For each species, cover was estimated as the proportion of the ground surface occupied by a perpendicular projection of the plant foliage, attempting to take overlap into account (Grieg-Smith 1964). The statistical significance of pre-spray differences in vegetation among the treatment-plots was tested by analysis of variance. Significant differences from the ANOVA were assessed using Duncan's multiple range test (Ott 1977). In this analysis, the pre-spray treatment-plots were considered to be replicates with internal sub-sampling. Since the spray treatments were not replicated, it was impossible to separate location (block) effects from treatment effects (Hulbert 1984) once the plots were sprayed. Therefore, our post-spray analysis of vegetation data involved the use of relatively simple statistical tests to draw out major points of biological interest (Chatfield 1985). For each treatment-plot, paired t-tests were used to determine whether the vegetational differences between years were statistically significant. This procedure is used to determine the statistical significance of differences between dependent samples (Ott 1977), as in this study where vegetation was sampled in permanent quadrats. For the cover data only, arcsine square root transformations were used (Sokal and Rohlf 1974).

Breeding birds were censused using the spot-mapping method (Williams 1936; IBCC 1970; Robbins 1978). Each plot was surveyed ten times (7-8 dawn and 2-3 dusk censuses) between 22 May and 28 June 1984. The density of breeding pairs was expressed as pairs/10 ha for species having ≥ 0.5 territory/plot. Bird species diversity was calculated as $H' = -\sum p_i \cdot \ln p_i$ (Shannon and Weaver 1949), where p_i is the relative density of species i . Because of the sampling design, which involved a whole-plot census of essentially unreplicated treatments, we did not test for the statistical significance of differences in avian density among treatments.

Small mammals were surveyed with Victor snaptraps baited with peanut butter and rolled oats. Three traps were placed within a 1 m radius at stations located at 10 m intervals along a single transect through the length of each treatment-plot. The number of sampling stations ranged from 26

to 30. Sampling was done for three consecutive nights during each of three intervals in 1984 (28-30 June, 31 July - 2 August, 28-30 August). Abundance was standardized as the number of captures per 100 trap-nights. One-way ANOVA calculations were based on the number of captures per night and sampling station. H' was calculated using relative density to estimate p_i .

Results and Discussion

1. Vegetation.

The description of vegetation changes presented here is relatively superficial. A detailed, species-specific analysis is on file. [R. Morash, B. Freedman, and C. Stewart. 1986. Initial impacts of silvicultural herbicide spraying on the vegetation of regenerating clearcuts in central Nova Scotia. Research Report to the Canadian Forestry Service. On file at Department of Biology, Dalhousie University, Halifax, N.S.]

After spraying, most of the live shrub stems on the unsprayed plots had a reduced leaf cover because of defoliation by the 2,4,5-T (Table 1). For example, compared with the 1983 pre-spray condition, the average foliage cover of Red Maple decreased in 1984 by a factor of 70% on the 1X plot ($p = 0.02$) and by 84% on the 2X plot ($p = 0.02$), whereas it increased by 25% on the unsprayed plot ($p < 0.01$). Because of plant growth on the reference plot, the SBA of Red Maple increased by 13% (n.s.) between the 1983 and 1984 samplings, while stem density was little changed. However, because of herbicide-caused mortality the SBA of foliage-bearing stems of Red Maple on the 1X spray plot decreased by 47% ($p = 0.05$) and stem density by 25% (n.s.), and on the 2X spray plot SBA decreased by 19% and density by 25% (both n.s.). Birches increased in foliage cover by 80%, in SBA by 80%, and in density by 22% on the unsprayed plot (all $p < 0.001$), whereas because of mortality these decreased by 4% (n.s.), 51% ($p = 0.005$), and 62% ($p = 0.004$) respectively on the 1X spray plot, and by 74% ($p < 0.001$), 62% ($p = 0.04$), and 67% ($p = 0.009$) on the 2X plot. Red Raspberry increased in cover by 22% ($p = 0.03$) and in stem density by 35% ($p = 0.005$) on the unsprayed plot, but on the 1X spray plot these decreased by 20% ($p = 0.04$) and 24% ($p = 0.004$) respectively, and on the 2X plot by 63% ($p < 0.001$) and 28% ($p = 0.005$). Considering all shrub species in aggregate, on the unsprayed plot foliage cover increased by 29% ($p < 0.001$), live SBA by 34% ($p < 0.001$), and stem density by 29%

TABLE 1. Selected characteristics of the vegetation of the treatment-plots prior to the spraying of 2,4,5-T, and in the first post-spray year. The data are average values ($\pm$ S.E.) of $n = 125 \times 5$ m quadrats for SBA and density of shrub-sized vegetation, and $n = 48 \text{ } 1 \times 1$ m quadrats for foliage cover.

Spray Treat- ment	Vegetation	Pre-spray			First-year Post-Spray		
		SBA (m ² /ha)	Density (10 ³ /ha)	Cover (%)	SBA (m ² /ha)	Density 10 ³ /ha)	Cover (%)
0X	<i>Acer rubrum</i>	1.11 $\pm$ 0.60	14.0 $\pm$ 5.4	8.3 $\pm$ 6.2	1.25 $\pm$ 0.75	13.1 $\pm$ 3.8	#10.4 $\pm$ 6.3
	<i>Betula</i> spp.	0.43 $\pm$ 0.09	26.3 $\pm$ 6.0	3.1 $\pm$ 0.7	#0.77 $\pm$ 0.16	#32.0 $\pm$ 6.6	#5.6 $\pm$ 1.3
	<i>Rubus</i> spp.	0.63 $\pm$ 0.14	85.1 $\pm$ 19.3	17.2 $\pm$ 4.5	#0.86 $\pm$ 0.16	115 $\pm$ 22	#20.9 $\pm$ 2.8
	All shrub species	2.45 $\pm$ 0.70	147 $\pm$ 24	29.3 $\pm$ 7.7	#3.28 $\pm$ 0.78	#190 $\pm$ 30	#37.8 $\pm$ 7.0
	All pteridophytes			27.5 $\pm$ 7.2			25.4 $\pm$ 6.1
	All monocots			8.5 $\pm$ 2.5			#11.0 $\pm$ 2.5
	All dicots			43.4 $\pm$ 6.4			#56.1 $\pm$ 6.6
	All plants			89.1 $\pm$ 8.3			#103 $\pm$ 8
1X	<i>Acer rubrum</i>	1.53 $\pm$ 0.61	9.1 $\pm$ 2.6	14.8 $\pm$ 6.2	#0.81 $\pm$ 0.34	6.8 $\pm$ 1.7	#4.5 $\pm$ 1.9
	<i>Betula</i> spp.	*1.04 $\pm$ 0.27	51.5 $\pm$ 12.4	5.3 $\pm$ 0.8	#0.51 $\pm$ 0.16	#19.6 $\pm$ 4.2	5.1 $\pm$ 1.1
	<i>Rubus</i> spp.	*1.26 $\pm$ 0.14	*174 $\pm$ 19	*30.0 $\pm$ 3.2	#0.96 $\pm$ 0.09	#133 $\pm$ 13	#24.1 $\pm$ 3.2
	All shrub species	4.03 $\pm$ 0.65	*253 $\pm$ 22	*52.2 $\pm$ 7.0	#2.51 $\pm$ 0.36	#176 $\pm$ 11	#35.5 $\pm$ 3.9
	All pteridophytes			*3.6 $\pm$ 1.2			#4.6 $\pm$ 1.4
	All monocots			8.8 $\pm$ 2.9			#10.6 $\pm$ 2.5
	All dicots			69.8 $\pm$ 6.5			53.8 $\pm$ 3.9
	All plants			90.8 $\pm$ 7.4			#78.3 $\pm$ 5.2
2X	<i>Acer rubrum</i>	1.29 $\pm$ 0.98	8.7 $\pm$ 4.4	12.2 $\pm$ 5.0	1.05 $\pm$ 1.01	6.5 $\pm$ 4.0	#1.9 $\pm$ 0.9
	<i>Betula</i> spp.	0.45 $\pm$ 0.13	20.4 $\pm$ 5.3	2.7 $\pm$ 0.5	#0.17 $\pm$ 0.10	#6.8 $\pm$ 4.0	#0.7 $\pm$ 0.3
	<i>Rubus</i> spp.	*1.10 $\pm$ 0.15	*155 $\pm$ 21	*39.3 $\pm$ 3.2	#0.80 $\pm$ 0.14	#111 $\pm$ 17	#24.6 $\pm$ 2.8
	All shrub species	2.99 $\pm$ 0.88	195 $\pm$ 22	*54.5 $\pm$ 6.0	#2.16 $\pm$ 0.97	#134 $\pm$ 20	#27.2 $\pm$ 2.9
	All pteridophytes			14.8 $\pm$ 3.3			#19.0 $\pm$ 4.5
	All monocots			4.0 $\pm$ 0.8			#6.0 $\pm$ 1.0
	All dicots			70.3 $\pm$ 5.9			#44.1 $\pm$ 3.0
	All plants			95.7 $\pm$ 6.2			#73.8 $\pm$ 3.7

*significantly different ($p < 0.05$) from the 0X treatment in the pre-spray sampling; F-tests
#significant change ($p < 0.05$) from pre-spray condition; paired t-tests.

($p = 0.005$), while on the 1X plot these decreased by 32% ($p = 0.004$), 38% ($p = 0.01$), and 30% ($p < 0.001$) respectively, and on the 2X plot they decreased by 50% ($p < 0.001$), 28% ($p = 0.02$), and 31% ($p = 0.003$).
In the first growing season after spraying, the cover of ground vegetation averaged 103%, 78%, and 74% respectively, on the unsprayed, 1X sprayed, and 2X sprayed treatment-plots (Table 1). Compared with their 1983 pre-spray condition, these represent a relative increase in cover of 16% ($p < 0.001$) on the unsprayed plot, a decrease of 14% ($p = 0.03$) on the 1X spray plot, and a decrease of 23% ($p < 0.001$) on the 2X plot. Pteridophytes are not susceptible to 2,4,5-T. The average cover of pteridophytes was changed marginally on the unsprayed plot between 1983 and 1984, while on both spray plots it increased by 28% (both

$p \leq 0.04$). Monocotyledonous plants are also not susceptible to 2,4,5-T. Monocot cover increased on all plots, by 29% on the unsprayed plot, 20% on the 1X spray plot, and 50% on the 2X plot (all $p < 0.001$). Most dicotyledonous plants are susceptible to damage from 2,4,5-T. The cover of herbaceous dicot plants increased by 30% ($p < 0.001$) on the reference plot, and there was also a small increase of 4%-7% (both n.s.) on the two sprayed plots. Although the 2,4,5-T caused much mortality of dicot herbs, there was also substantial regeneration of this group of plants in the first post-spray growing season. Various species of Asteraceae were especially prominent in the post-herbicide regeneration. In the first year after spraying, the cover of Asteraceae increased by a factor of 27% ($p = 0.006$) on the 1X plot, and by 37% ($p = 0.004$) on the 2X plot, while on the reference plot it increased by 49% ($p < 0.001$).

TABLE 2. Breeding birds on the 2,4,5-T spray plots. Data are in pairs/10 ha; richness d = the number of species; diversity = $-\sum p_i \cdot \ln p_i$.

Species	unsprayed	1X spray A	1X spray B	2X spray
American Woodcock			1.3	
Ruby-throated Hummingbird			1.3	
Olive-sided Flycatcher			1.3	
Alder Flycatcher	2.0			
American Robin	1.0	1.2	1.3	0.9
Mourning Warbler	5.1	2.5	3.8	2.6
Common Yellowthroat	24.4	24.6	26.9	18.8
Song Sparrow	4.1	7.4	3.8	1.7
Lincoln's Sparrow	2.0	6.1	2.6	3.4
White-throated Sparrow	19.3	22.1	20.5	16.2
Northern Junco	9.2	4.9	9.0	5.1
American Goldfinch	4.1	7.4	5.1	1.7
TOTAL DENSITY	71.2	76.2	76.9	50.4
SPECIES RICHNESS*	17	11	19	12
SPECIES DIVERSITY*	1.76	1.73	1.84	1.60

*includes transients and species with $< 1/2$ territory per plot.

2. Breeding Birds.

There were small differences in the density of breeding birds among the herbicide treatment-plots in the first post-spray growing season (Table 2). All of the treatment-plots had the same dominant species of bird, and the relative abundance of these were similar. For example, the Common Yellowthroat accounted for 34% of the total bird density on the unsprayed plot, 32% and 35% on the two 1X spray plots, and 37% on the 2X plot, while the White-throated Sparrow was 27%, 29%, 27%, and 32% respectively. All of the common breeding species had a smaller absolute density on the 2X plot, which averaged 29%-34% fewer individuals than on the reference plot or on the two 1X spray plots. However, no bird species were eliminated from the 2X plot. Overall, in the first post-spray year the habitat changes caused by the 2,4,5-T treatment appears to have caused no more than a minor difference in the breeding birds of the various treatment-plots of this conifer clearcut.

Few other studies have reported the effects of silvicultural herbicide spraying on birds. As in our study, Morrison and Meslow (1984a,b) reported only moderate differences in the breeding birds of herbicide-sprayed and unsprayed clearcuts in Oregon. A much larger change in the breeding bird community, particularly in species composition, takes place when mature forest is clearcut (Franzreb 1978; McArthur 1980; Freedman *et al.* 1981; Welsh 1981; Morgan and Freedman 1986).

3. Small Mammals.

The overall abundance and diversity of small mammals did not differ ($p > 0.05$) among the treatment-plots in the first post-spray year (Table 3). Variable results have been reported among the few studies that have examined the effects of silvicultural herbicide treatments on small mammals. Borrecco *et al.* (1979) found no effect on the overall abundance of small mammals, but reported a change in species composition. Both Savidge (1978) and Kirkland (1978) found an increase of total abundance, but little change in species composition. Spencer and Barrett (1980) found that the abundance of Meadow Voles decreased by one-half after herbicide spraying.

Conclusions

Shrub-sized angiosperm plants were greatly decreased in abundance as a result of mortality caused by the 2,4,5-T spray treatment. The primary intent of the herbicide treatment was, in fact, to achieve this ecological effect. The ground vegetation of the spray plots suffered somewhat less mortality, but there were large changes in species composition because of differential susceptibility of taxa to the 2,4,5-T. In spite of the large changes in the structure and plant species composition of the vegetation of the sprayed plots, an important effect on the abundance and species composition of breeding birds and small mammals was not apparent.

TABLE 3. Small mammal abundance (no./100 trap-nights) for the various treatment plots.

Species	unsprayed	IX spray A	IX spray B	2X spray
Masked Shrew	6.8	8.9	7.2	7.5
Smoky Shrew	1.0	1.0	1.0	0.0
Short-tailed Shrew	0.9	1.4	2.3	1.2
Pygmy Shrew	0.4	0.7	0.0	0.1
Arctic Shrew	0.0	0.0	0.0	0.1
Red-backed Vole	1.0	0.5	0.5	0.3
Meadow Vole	0.9	1.5	1.3	1.6
White-footed Mouse	0.6	0.1	0.6	0.5
Deer Mouse	0.6	0.1	0.6	0.1
Meadow Jumping Mouse	0.6	0.1	0.0	0.3
TOTAL	12.8	14.3	13.5	11.7
SPECIES DIVERSITY	1.68	1.36	1.45	1.30

Note: 562 individuals were captured in 5128 trap-nights (11% capture efficiency).

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Appendix 1. Binomials of organisms mentioned in the manuscript.

A) PLANTS

- Black Spruce, *Picea mariana* (Mill.) BSP.
Norway Spruce, *Picea abies* L.
birches, *Betula* L. spp.; esp. White Birch, *B. papyrifera*
Marsh raspberries, *Rubus* L. spp.; esp. Red Raspberry,
R. strigosus Michx.
Red Maple, *Acer rubrum* L.

B) MAMMALS

- Masked Shrew, *Sorex cinereus* Kerr
Smoky Shrew, *Sorex fumeus* Miller
Arctic Shrew, *Sorex arcticus* Kerr
Pygmy Shrew, *Microsorex hoyi* (Baird)
Short-tailed Shrew, *Blarina brevicauda* (Say)
Deer Mouse, *Peromyscus maniculatus* (Wagner)
White-footed Mouse, *Peromyscus leucopus*
(Rafinesque)
Red-backed Vole, *Clethrionomys gapperi* (Vigors)
Bog Lemming, *Synaptomys cooperi* Baird
Meadow Vole, *Microtus pennsylvanicus* (Ord)
Meadow Jumping Mouse, *Zapus hudsonicus*
(Zimmermann)
Woodland Jumping Mouse, *Napaeozapus insignis*
(Miller)

C) BIRDS

- American Woodcock, *Philohela minor* (Gmelin)
Ruby-throated Hummingbird, *Archilochus colubris*
(Linnaeus)
Olive-sided Flycatcher, *Contopus borealis* (Swainson)
Alder Flycatcher, *Empidonax alnorum* Brewster
American Robin, *Turdus migratorius* Linnaeus
Mourning Warbler, *Oporornis philadelphia* (Wilson)
Common Yellowthroat, *Geothlypis trichas* (Linnaeus)
Song Sparrow, *Melospiza melodia* (Wilson)
Lincoln's Sparrow, *Melospiza lincolni* (Audubon)
White-Throated Sparrow, *Zonotrichia albicollis*
(Gmelin)
Northern Junco, *Junco hyemalis* (Linnaeus)
American Goldfinch, *Spinus tristis* (Linnaeus)

Migratory Patterns of the Wapiti, *Cervus elaphus*, in Banff National Park, Alberta

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Morgantini, L. E., and R. J. Hudson. 1988. Migratory patterns of the Wapiti, *Cervus elaphus*, in Banff National Park, Alberta. *Canadian Field-Naturalist* 102(1): 12-19.

Migratory behavior of the Wapiti along the eastern boundary of Banff National Park was studied over a three-year period. Most of the Wapiti population which summers on alpine ranges in the northern half of Banff National Park was found to migrate on to three winter ranges outside the park. Minimum distances between summer and winter ranges varied from 26 to 68 km. The entire yearly migratory cycle consisted of 52 to 138 km of mountain travel and a minimum total elevation change of 2000 m. Wapiti exhibited predictable movement patterns and a tendency to return to the same ranges each year. This migratory pattern is interpreted as a vestige of the dispersal of Wapiti from the Bow River valley in Banff National Park after their re-introduction in the years 1917 and 1920.

Key Words: Wapiti, Elk, *Cervus elaphus*, migration, Banff National Park, Alberta.

In mountainous regions of North America, most Wapiti, *Cervus elaphus*, populations migrate between seasonal ranges (Altmann 1952; Craighead et al. 1972). Migratory behavior may vary from local movements of 2 to 4 km (Anderson 1958; Dalke et al. 1965) to migrations of more than 100 km (Skinner 1925; Anderson 1958). Within the same population, migratory and non-migratory behavior may be present (Martinka 1969; Boyd 1970). Some herds exhibit spring and summer migrations, while others remain on winter ranges until early summer (Knight 1970).

Within the diversity of migratory behavioral patterns, Wapiti show considerable fidelity to seasonal ranges year after year (Murie 1951; Altmann 1952; Anderson 1958; Knight 1970). In the Yellowstone National Park area, most animals return to different winter ranges, even though mingling occurs on summer ranges, and thus maintain distinct herd entities (Craighead et al. 1972). The same migratory routes may be used each year (Altmann 1952; Anderson 1958).

While migratory behavior of Wapiti populations in the United States has been well documented, knowledge of migrations in the Canadian Rocky Mountains is limited to observations of seasonal range use and distributions obtained incidentally during studies of herbivore interactions, population dynamics, or Wolf, *Canis lupus*, predation (Cowan 1950; Flook 1970; Carbyn 1974; Stelfox 1976).

The objective of this study was to determine Wapiti distribution and movements in the Panther, Red Deer and Clearwater rivers region and to assess whether present migratory patterns

can be related to the dispersal of Wapiti from the Bow River valley in Banff National Park after their re-introduction in the years 1917 and 1920.

Study Area

The study was conducted along the Canadian Rocky Mountains, in west-central Alberta (Morgantini 1988). The study area includes over 4000 km² of mountain terrain, 80% of which is within the boundary of Banff National Park. It includes four major river valleys: the Red Deer, Clearwater, Panther and Pipestone rivers. Elevation ranges between 1500 m on valley floors and 2600 m on alpine sites.

Three ecoregions are identified (Holland and Coen 1985; Stelfox 1981). The alpine ecoregion occurs at elevations above 2300 m, and is characterized by the absence of trees and presence of cold harsh climatic conditions. Plant communities are those typical of alpine heath tundra. The subalpine ecoregion ranges between 1600 m and 2300 m. Forests are dominated by Engelmann Spruce (*Picea engelmannii*) and Subalpine Fir (*Abies lasiocarpa*). White Spruce (*Picea glauca*) and Lodgepole Pine (*Pinus contorta*) are found at lower elevations.

A third ecoregion, Montane, is restricted to alluvial meadows along the main river valleys 5 to 10 km outside Banff National Park: the Ya Ha Tinda Ranch along the Red Deer River, the "Corners" along the Panther River, and Harrison Flats along the Clearwater River. Due to the sheltering effect of the surrounding mountains, these meadows have mild winters. The vegetational mosaic is characterized by rolling, Rough

Fescue (*Festuca scabrella*) grasslands, which are kept largely snow free by strong westerly winds.

Methods

Most of the data on Wapiti movements and distribution was collected during extensive field surveys carried out on foot or on horseback throughout the study region. The study extended from December 1976 to November 1979. Every month an average of 15 days was spent in the field, for a total of 537 field-days. Field work consisted in locating Wapiti herds and in continuously monitoring, from day to day, their movements throughout the field period. Animal movements and distribution were photo-documented in the field and later transferred to 1:21 000 scale aerial photographs.

The identification of herds and the location of seasonal ranges were initially facilitated by the presence of 11 cows (six years old and older) equipped with neck collars. These animals had been collared in 1971 and 1973 by the Alberta Fish and Wildlife Division as part of an uncompleted study on Wapiti movements in the Ya Ha Tinda Ranch area along the Red Deer River (Rosin and Paulsen 1973. Alberta Fish and Wildlife unpublished report. 14 pp.). In order to further facilitate the identification of different herds and to follow the animals during their long seasonal movements, an additional four cows (five years old and older), four yearlings (two males and two females) and three calves (one male and two females) were trapped and radio-collared.

Ground surveys were complemented by aerial surveys. During the summers of 1977 and 1978, seven aerial surveys (27.4 hours) were carried out with a Bell 206 helicopter. The study area was surveyed by flying all the major and secondary valleys in a pattern to allow maximum coverage of alpine-subalpine ranges and of meadows and forests in the region. In the winters of 1976-77, 1977-78, and 1978-79, aerial surveys were conducted by the Banff National Park Warden Service and by Alberta Fish and Wildlife Division inside and outside the National Park, respectively (Banff National Park files; Alberta Fish and Wildlife files).

Results

During the three-year study 652 groups, comprising a total of 14 758 animals, were observed (Table 1). Collared animals were present in 199 observations for a total of 248 sightings. Most observations were recorded in the Red Deer River watershed, which supported an estimated

population of 600 animals. Wapiti along the Little Pipestone and the Pipestone rivers were found to be part of the herd that winters along the Red Deer River. The Clearwater and the Panther river watersheds each supported about 200 individuals. The entire yearly migratory cycle in the region is summarized in Figure 1. It involved 52-138 km of mountain travel (Table 2), and a minimum total elevation change of 2000 m.

Winter distribution (December-April)

Between December and April Wapiti were mostly found outside Banff National Park. During this study, Wapiti did not winter in the Pipestone River drainage. Within the Red Deer River drainage, large cow-calf-juvenile herds (50-400 individuals) wintered on the open grassland in the Ya Ha Tinda Ranch region, while smaller cow herds and bulls were observed in the surrounding areas. Only a few Wapiti remained through the winter in Banff National Park. Along the Clearwater River Wapiti made extensive use of several open meadows and south-facing slopes 2-12 km outside the National Park boundary. The use of ranges in the National Park was limited.

Within the Panther River watershed, Wapiti wintered in significant numbers both inside and outside Banff National Park. Outside the National Park, most observations were recorded in the "Corners" region. In Banff National Park Wapiti wintered throughout the Panther River valley. A large number of bulls and a few cows were found wintering on higher subalpine meadows along the Panther-Red Deer river divide. Movements across the boundary of the National Park were also detected. However, it could not be determined whether they reflected normal movement patterns or whether they were caused by recreational activities (snowmobiling, etc.) in the "Corners" area.

During special winter hunting seasons (January-February 1977 and 1978), Wapiti returned to Banff National Park and heavily used small grassland meadows along the Red Deer River valley. Other herds moved from the "Corners" and from the Ya Ha Tinda Ranch on to surrounding high elevation ranges (Morgantini and Hudson 1985). However, in three to five days following the hunting seasons, the animals re-established their habitual range outside the National Park.

Summer Distribution (July-August)

During July and August 1977, 1978 and 1979, a total of 1417 Wapiti were counted in 118 observations. Collared animals were present in 66 groups.

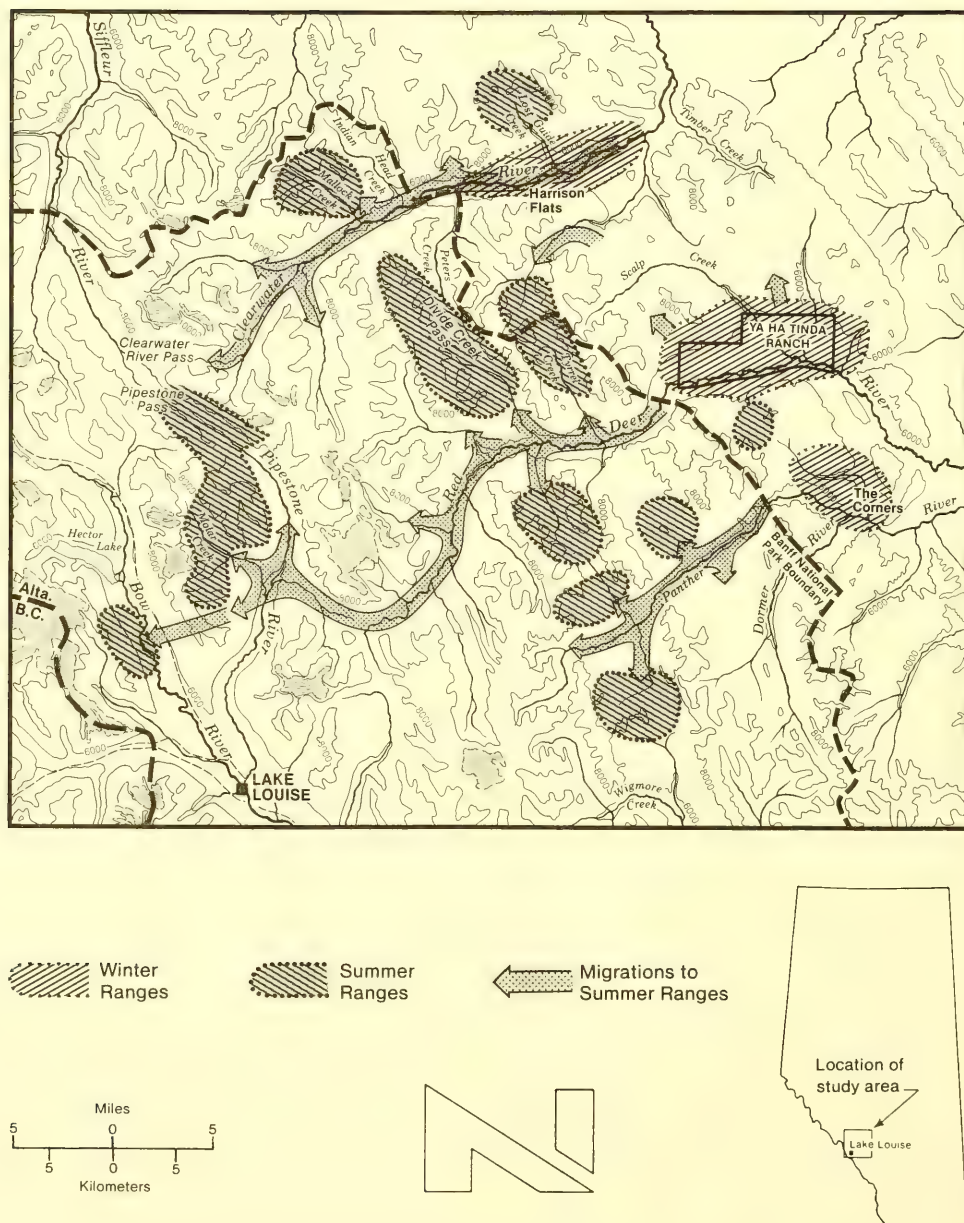


FIGURE 1. Wapiti migrations from winter to summer ranges in Banff National Park (1977-1979).

In the summer, Wapiti were mostly found within the boundary of Banff National Park and were widely dispersed over some 1600 km² of mountain terrain. Out of 22 collared animals, 10 were always found to summer in the Pipestone-Lake Louise area, seven in the Red Deer River watershed, one

along the Panther River, and two in the Clearwater River region. Two animals were never located and were presumed dead.

Large herds (30-70 animals) ranged on high subalpine and alpine meadows at the headwaters of several tributary creeks of the Red Deer,

TABLE 1. Summary of Wapiti observations and estimated population sizes in the study region (1977-1979).

River Drainage	Estimated Pop. size	No. of observations			
		Winter (Dec.-Apr.)	Spring (May-June)	Summer (July-Aug.)	Fall (Sept.-Nov.)
Red Deer*	600	175 (8144)	122 (154)	80 (994)	57 (751)
Clearwater	200	47 (343)	31 (613)	13 (122)	11 (149)
Panther	200	38 (916)	24 (387)	24 (301)	30 (184)
TOTALS	1000	260 (9403)	177 (2854)	117 (1413)	98 (1084)

*The animals that summer in the Pipestone River were found to be part of the herd that winters in the Red Deer River region.

() = total number of animals counted.

Panther and Clearwater rivers. Approximately 200 to 250 Wapiti, more than 30% of the Ya Ha Tinda Ranch winter herd, summered in the Pipestone-Lake Louise area. However, small herds of cows (1-10 animals) and bulls, and signs of their activity, were found throughout the National Park wherever favorable habitat was available. Occasionally, Wapiti could also be observed along the main river valleys while travelling from or to their summer ranges.

Between 1977 and 1979 less than 10% of the total winter population of the region summered outside Banff National Park. They consisted largely of small herds of cows and calves and isolated bulls. The highest number (30 animals) was observed in the Clearwater watershed.

In the summer of 1977, a herd of 34 animals (5 bulls, 21 cows with two collared individuals and 8 calves) remained on the Ya Ha Tinda Ranch until the third week of July. Following human harassment (hikers and trail riders), the animals moved first on to the surrounding slopes and ridges where they remained until the first week of August. After continuing harassment by 4X4 vehicles, the animals left the region and moved on to alpine ranges, 24 km distant, in Banff National Park.

Spring and Fall Migrations (May-June and September-November)

Wapiti exhibited well-defined seasonal migrations between winter and summer ranges. The minimum distance travelled from winter ranges varied from 26 to 68 km (Table 2).

Spring migrations consisted of an initial gradual shift from winter ranges to ranges located farther west along the major river valleys (spring "intermediate" ranges). This movement was later followed by a rapid altitudinal migration to high elevation ranges. The timing of spring migrations showed great variation. Even though some animals were observed leaving their winter range in early May, most moved during the second half of May and in early June.

The location and level of utilization of intermediate ranges depended on the date the animals left their common winter range and on the distance between winter ranges and individual summer ranges. Within the Red Deer watershed, animals that summered close to the Ya Ha Tinda Ranch winter range remained along the Red Deer River valley until early July. In contrast, the segment of the population with summer ranges in the Pipestone-Lake Louise area continued its

TABLE 2. Distance of summer ranges in Banff National Park of 18 Wapiti collared on the Ya Ha Tinda Ranch (1977-1979).

N	Linear distance (km)				Minimum travel distance* (km)		
	Average	Range	S.D.		Average	Range	S.D.
21	36.7	17.5-57.5	14.1		49.8	26.5-67.5	17.9

Note: During the study two animals used different summer ranges.

* Minimum travel distance along river valleys.

gradual movement westward along the Red Deer and the Pipestone rivers. Some of these animals left the Ya Ha Tinda Ranch in the middle of May and by early June had established their spring "intermediate" ranges (55 km distant) along the Pipestone River. Others never established actual intermediate ranges, but, having left their winter range at a later date, used the entire month to gradually shift on to summer ranges in the upper Pipestone River.

Spring migrations overlapped the calving season (25 May-5 June). Calving was observed throughout the region, both on winter and on intermediate ranges, and it appeared to slow spring movements. Due to the proximity of summer and winter ranges along the Clearwater and the Panther rivers, intermediate ranges and winter ranges coincided for those few Wapiti that spent the summer outside Banff National Park.

Fall migrations towards winter ranges occurred between September and November. Initially, they consisted of a rapid shift on to lower elevation ranges along the major river valleys (intermediate ranges). This movement coincided with early snowfall (Table 3). Temporary returns to higher elevation ranges during warm fall weather, one to two days following snowfall, were also observed. By the end of September, most of the Wapiti population was found on intermediate ranges. During the month of October, instead of gradually shifting onto winter ranges, Wapiti concentrated on intermediate ranges just inside Banff National Park. These sites acted as major "staging areas" for

large herds before their late fall-early winter (15 November-15 December) movements onto winter ranges outside the National Park.

Along the Clearwater River, Wapiti tended to move outside the National Park earlier.

Range fidelity

Throughout the study region, Wapiti seemed to exhibit predictable movement patterns between ranges and a general tendency to return to the same ranges each year. The relatively low percentage of the total population collared (4% of the Red Deer River herd) does not allow a quantitative assessment of range fidelity. Nonetheless, the frequency of return of collared animals to specific summer ranges and their return to a common winter range are a clear indication of a well-developed habitual behavior (Table 4). This behavior was further manifest in the use of the same migratory trails connecting different seasonal ranges.

Between 1977 and 1979 11 out of 18 collared Wapiti returned to the same summer ranges. For eight of these animals, spring movements to their traditional ranges involved more than 60 km of travel across trails which allowed access to summer ranges closer to their wintering grounds.

In winter, 16 out of 18 collared Wapiti returned to their common winter range for four successive years. Two males, trapped and collared as 10-month-olds in March 1978, returned to the Ya Ha Tinda Ranch only the following winter. After moving to their habitual summer ranges in 1979,

TABLE 3. Elevational distribution of Wapiti before, during, and after early snowfalls in 1977 and 1978.

Date	Elevation (m) ($\bar{x} \pm S.D.$)	Total snowfall at 1650 m	No. of observations
1977			
9-10 September	2181 $\pm$ 253a	0.0	6 (105)
13-16 September	1746 $\pm$ 102bc	15.0*	13 (93)
17-26 September	2028 $\pm$ 192ad	0.0	19 (131)
27-30 September	1741 $\pm$ 18bc	6.4**	15 (148)
1978			
11-17 September	2030 $\pm$ 194	0.0	8 (66)
18-19 September	1877 $\pm$ 101	13.0*	10 (78)
20-28 September	2077 $\pm$ 142	0.0	11 (134)

Values within columns followed by different letters are significantly different at $P < 0.05$ (T-test).

*Snowfall over the entire period.
**Snowfall on 27 September.
() Total number of animals observed.

they were not relocated. Both animals were shot by hunters outside the National Park — one in the fall of 1980 along the Clearwater River, the other in the fall of 1981 between the Panther and the Red Deer rivers.

Based on these data and on field observations, the Wapiti population in the region can be subdivided into three separate herds, each associated with a major river valley (i.e. Panther, Red Deer and Clearwater). Some mingling between herds on summer ranges was detected. In early fall the great majority of the animals that had shifted to another drainage were observed to move back to their habitual ranges. Further mingling between the Panther River and the Red Deer River herds appeared to occur in the late fall and winter, especially during intensive hunting harassment.

Movements of Wapiti from and to areas adjacent to the study region were observed. While no evidence was ever found of movements from the Red Deer herd across Pipestone Pass into the Siffleur River, travel through Clearwater Pass into the Siffleur River valley was detected. Mingling also occurs between the Red Deer River and the Bow River herds as indicated by the presence in 1977 of two collared Wapiti from Kootenay National Park in the Molar Creek area and on the Ya Ha Tinda Ranch. During 1978, two more Wapiti not collared during this study were found within the Red Deer River herd. They had been trapped in Jasper National Park and released by the Alberta Fish and Wildlife Division in 1974 along the Red Deer River east of the Front Ranges 25 km from the Ya Ha Tinda Ranch.

TABLE 4. Number of collared animals that returned to the same ranges in successive years (1977-1980).

No. of successive years	Number of animals that returned to the same ranges	
	Summer ranges	Winter ranges
0	2	0
1	3	2
2	2	0
3	11	0
4	*	16

Note: The table does not include two animals that were never found and presumably died during the first winter and 2 animals that were shot by hunters outside Banff National Park.

*Systematic monitoring of summer ranges was carried out for only three years.

Discussion

The distribution of Wapiti observed during this study is consistent with observations recorded by Banff National Park wardens between 1949 and 1976 (Banff National Park files). The stability of regional movements and distribution is further confirmed by 11 ground surveys carried out by L.E.M. between 1980 and 1983, and by more recent Banff National Park wildlife surveys (Banff National Park files). Seasonal distribution and movement patterns in the study region are also consistent with knowledge of Wapiti behavior in mountain environments (Adams 1982).

The winter concentration of Wapiti on the Ya Ha Tinda Ranch reflects the availability of open winter ranges. The area represents less than 4% of the entire region and, due to its mild winter weather and mostly snow free conditions, is ideal winter range. In comparison, the "Corners" area along the Panther River and Harrison Flats and its adjacent south-facing slopes along the Clearwater River offer significantly less winter range and indeed support smaller numbers of animals (Morgantini and Bruns 1984).

In this typical northern mountain environment, Wapiti appear to respond to seasonal environmental changes with shifts from low elevation winter and intermediate ranges (1500-1600 m) to high elevation summer ranges (2100-2400 m), and vice versa (Morgantini 1988). In the study region the location of summer ranges and range fidelity indicate that tradition (learned behavior) plays a major role in shaping Wapiti distribution. The migration of approximately 200 animals from the Ya Ha Tinda Ranch to summer ranges north of Lake Louise and in the upper Pipestone River cannot be explained solely in terms of adaptation to seasonal environmental conditions. Migrating to summer ranges north of Lake Louise, for instance, involves an initial travel of 40 km along the Red Deer River valley to an elevation of 2100 m, then a downward movement of 25 km to an elevation of 1700 m and a final 2-3 km climb towards high elevation meadows. All along the route there are well-established trails to summer ranges significantly closer to the Ya Ha Tinda Ranch.

There are two possible explanations for this long-range migratory behavior. Yearly westward movements may reflect the original gradual dispersal and colonization of the region by animals wintering on a common winter range. Conversely, the entire migratory pattern may be a vestige of the original dispersal of Wapiti from the Bow River Valley. Historical evidence and this study tend to support the latter interpretation.

In the early 1900s, Wapiti had almost disappeared from the Canadian Rocky Mountains as a result of severe winters and indiscriminate hunting by white and native people (Millar 1915; Stelfox 1964; Soper 1970). The present population is believed to have originated from the release in Banff National Park, mostly along the Bow River valley, of between 245 and 251 animals from Wyoming between 1917 and 1920 (Lloyd 1927; Green 1946). It has been suggested that this introduced stock interbred with the few remnant native Wapiti and with Wapiti moving into Banff National Park from British Columbia (Holroyd and Van Tighem 1983: 416). The Wapiti population rapidly increased and colonized adjacent valleys. Historical records show a gradual dispersal southeast into the Cascade River valley (1925), along the Panther River (1927) and Snow Creek (1931) (Banff National Park files). These records and the existence of well-established trails from the Panther and the Dormer rivers into the Wigmore-Cascade area suggest that Wapiti dispersing from the Bow River valley reached the Panther River by following the Cascade River and then Wigmore Creek. The shift on to the Red Deer River valley may have occurred in the summer across Snow Creek or in winter through the lower Dog Rib Creek.

The presence of Wapiti from Kootenay National Park in the Red Deer River herd and the well-established migratory pattern from the Pipestone to the Red Deer River point to a second dispersal route. In the north-eastern section, Wapiti were first reported in 1930 along Mosquito Creek, in 1936 along the Saskatchewan River and in 1942 along the Pipestone River (Banff National Park files). It is here suggested that at the time some Wapiti from summer ranges in the upper Pipestone River travelled east along Little Pipestone River into the upper Red Deer River valley. The winter range on the Ya Ha Tinda Ranch may have been encountered by chance during downward movements along the Red Deer River valley. This movement may have been facilitated by the presence of a few Wapiti remnant from the native population.

In comparison with the Panther and the Red Deer rivers, access to the Clearwater River from the Bow River Valley is limited. Dispersal and colonization may have occurred from the Sifleur River or from the lower Red Deer River valley.

The dispersal of Wapiti from their site of re-introduction and the present day migratory pattern in the region conform to the theory of seasonal return migrations within familiar areas as developed by Baker (1978, 1982). The familiar area is defined as "the portion of the lifetime range from

any point in which an animal is capable of finding its way to any other point" (Baker 1978:378). It is initially established during the course of successive exploratory movements (Baker 1978) and is largely maintained or extended through social communication within family units (cow-calf; Murie 1951) or through association of inexperienced with experienced animals.

In the study region, exploratory and/or dispersal (Horn 1978) movements may have gradually led to the establishment of fairly separate familiar areas. The apparent mingling between herds inhabiting different watersheds and the occasional shifting of animals from one herd to the other may reflect a continuing process of extension of the familiar area of the individuals involved. The movements of herds from summer ranges outside Banff National Park on to range in the park following human harassment suggest that at least some Wapiti are familiar with a region significantly larger than the one they are inhabiting.

In conclusion, Wapiti, in their seasonal migrations in the study region, appear to use the same routes that the species followed during its dispersal from the Bow River valley after its re-introduction in 1917 and 1920. This dispersal and the establishment of regular seasonal movements may have been facilitated by the presence of remnant Wapiti in the region.

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Breeding Performance of Black-legged Kittiwakes, *Rissa tridactyla*, at a Small, Expanding Colony in Labrador

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The breeding performance of Black-legged Kittiwakes, *Rissa tridactyla*, was studied at the Gannet Islands, Labrador, in 1981 to 1985. In 1981–1983 median clutch size varied between 1.7 and 2.0 eggs and productivity averaged 1.1 to 1.3 chicks per breeding pair. In 1984 and 1985 however, very few pairs (10%) attempted to breed. In 1985 at least, this was part of a more general geographic trend in south-eastern Canada. Breeding by kittiwakes at the Gannet Islands was first recorded in 1972; between that date and 1984 the breeding population increased from 16 to 119 pairs.

Key Words: Black-legged Kittiwake, *Rissa tridactyla*, breeding distribution, breeding performance, Labrador.

The Black-legged Kittiwake, *Rissa tridactyla*, has a disjunct breeding distribution in eastern North America, with most of the population occurring in either the northern (i.e., SE Baffin Island, north to Jones Sound) or southern (Newfoundland and the Gulf of St. Lawrence) parts of the species' range (Brown et al. 1975). Kittiwakes probably started to breed in Labrador only recently; the first breeding record was of 16 occupied nests on Outer Gannet Island (54°00'N, 56°32'W) in 1972 (Nettleship and Lock 1974). Six years later (1978) there were 48 occupied nests on Outer Gannet and three nests on one (GC4: see Methods for details) of the nearby Gannet Islands (53°56'N, 56°32'W). In 1979 there were 40 nests on Outer Gannet and 10 on the same Gannet Island (D. N. Nettleship, unpublished).

During the breeding seasons of 1981–1983 we conducted studies of seabirds (mainly alcids) breeding at the Gannet Islands. Here we present information on the breeding performance of Black-legged Kittiwakes at the Gannet Islands, together with some further information on the kittiwakes on Outer Gannet Island. Short visits were made to the Gannet Islands and Outer Gannet in 1984 and 1985; observations from those periods are also reported.

Methods

Daily observations of kittiwake nests were made from a blind located about 50 m from the breeding area, between late May (1982 and 1983) or early June (1981) and late August. All kittiwake nests were located in a cove on one island (GC4: see below), and in 1981 and 1982 all nests could be

observed from the blind. In 1983, however, 10 nests were built in areas not visible from the blind. Using methods similar to those described by Birkhead and Nettleship (1980) we recorded the timing of breeding (date of first egg of each clutch), clutch size, and breeding success (number of young fledged from each nest). A chick was considered to have fledged once it made its first flight at age 35 days or more (see Swartz 1966). In 1984 and 1985 visits were made on 2–15 July and 3–15 July, respectively, during which periods nests were counted and their contents recorded at the Gannet Islands. At Outer Gannet also, nests were counted in both years. Code designations used to identify the six islands comprising the Gannet Islands archipelago (e.g., GC1, GC2, GC3, GC4, etc.) are those described in Birkhead and Nettleship (1987).

Results

During the study the number of kittiwakes breeding at the Gannet Islands (not including Outer Gannet) continued to increase (Table 1), with 26 nests (18 clutches) in 1981, 37 nests (31 clutches) in 1982, and 52 nests (at least 42 clutches) in 1983, 63 nests in 1984 and at least 58 in 1985. Up to 1983 all prospecting kittiwakes were seen in the vicinity of the breeding colony on GC4, but in 1983 prospectors were seen on other islands and three nests were built on GC1. We did not check the contents of these nests, but judging from the birds' behaviour we assume that no eggs were laid. In 1984 there were 5 nests on GC1; no count of nests was made on this island in 1985. At Outer Gannet the population apparently stabilized, with 57 nests in 1983, 56 in 1984, but in 1985 only 40 nests were

TABLE 1. Changes in the numbers of Black-legged Kittiwakes (pairs of nest-site holders) at the Gannet Islands and Outer Gannet Island since they were first discovered breeding there in 1972.

Year	Gannet Islands		Outer Gannet Island		Total nests
	Total nests	% nests with eggs	Total nests	% nests with eggs	
1972	0	0	16	?	16
1978	3	?	48	?	51
1979	10	?	40	?	50
1981	26	69	- ¹	-	-
1982	37	84	-	-	-
1983	52	81	57	?	109
1984	63	10	56	?	119
1985	58	5	40	?	98 ²

¹No data available.²Values may be low; 5 nests recorded on GCI in 1984 were not examined in 1985.

counted. An area on Outer Gannet which had contained 16 nests in 1984 held only the remains of nests in 1985.

Kittiwakes were present at the Gannet Islands colony each year when observations began. First and median egg dates were 20 and 21 June in 1981 (N = 18), 15 and 18 June (N = 31), and 4 and 8 June in 1983 (N = 42). The median laying date advanced by 13 days over these three years. The differences in laying dates between years were not related in any obvious way to environmental conditions. In both 1981 and 1983 air temperatures and the timing of ice break-up were similar, whereas in 1982 (and 1984 and 1985; see below) temperatures were relatively low and ice break-up late [early June] (Birkhead and Nettleship 1987).

Mean clutch sizes (and the numbers of 1-, 2- and 3-egg clutches) were 1.67 (6, 12, 0; N = 18) in 1981, 1.87 (6, 23, 2; N = 31) in 1982, 2.02 (4, 33, 5; N = 42) in 1983. Sample sizes are too small for detailed statistical analysis, but a comparison of the proportion of 1-egg clutches versus 2- and 3-egg clutches (combined) showed no significant differences during 1981-1983 ($\chi^2 = 5.03$, 2 d.f., NS). However, over that three-year period the proportion of 1-egg clutches decreased (33%, 19% and 9% in 1981-1983, respectively), and the proportion of 3-egg clutches increased (0%, 6% and 12%, respectively). The overall increase in mean clutch size over those three years was probably related either to the timing of breeding, the change in age-structure of the population (cf. Coulson and Thomas 1985), or both. In 1984, 52 (90%) of the 58 nests examined on GC4 contained no eggs at a date when in previous years all birds would have laid. Four nests contained 1 egg, and 2

had 2 eggs. Similarly, in 1985, 55 (95%) of the 58 nests examined had no eggs, and 3 (5%) contained a single egg. As observations were limited we cannot exclude the possibility that most birds had laid and lost their eggs by the time observations were made, but it seems more likely that most birds failed to lay at all (see below).

In 1981-1983 the mean intervals between the laying of first and second eggs of 2- and 3-egg clutches did not differ significantly between years (1981, 2.43 ± 0.55 S.D., N = 7; 1982, 2.66 ± 1.2 , N = 9; 1983, 2.29 ± 0.08 , N = 28; $F_{2,41} = 0.7$, NS). Nor was there any inter-year difference in mean incubation periods (1981, 27.3 ± 0.9 S.D., N = 7; 1982, 27.5 ± 1.7 , N = 13; 1983, 27.1 ± 1.2 , N = 16; $F_{2,33} = 0.4$, NS).

Breeding performance of birds on GC4 for each year is summarized in Table 2. In general pairs laying larger clutches produced the greatest mean number of fledged chicks. Considering all clutch sizes, productivity (fledglings/breeding pair) differed rather little between years in 1981-1983 (Table 2), but the proportion of pairs rearing at least one chick to fledging was significantly lower in 1983 [26 out of 42 pairs (62%)] than in either 1981 [16/18 (89%)] or 1982 [26/31 (84%)] ($\chi^2 = 6.9$, 2 d.f., $P < 0.05$). The reason for reduced productivity in 1983 is not clear, but occurred as a result of high egg loss. In June 1983, 10 out of 27 nests with eggs (37%) lost one or two eggs (14 in total) between 18:00 on 9 June and 08:00 on 10 June. Two days later 6 out of 30 nests with eggs lost a total of 8 eggs overnight. We are uncertain about the cause of egg-loss in 1983; we never saw potential avian predators such as Common Raven, *Corvus corax*, or Great Black-backed Gull, *Larus*

TABLE 2. Population size and breeding performance of Black-legged Kittiwakes at the Gannet Islands (GC4), 1981-1985.

Year	Clutch size (eggs)	No. of pairs	Total no. eggs	Eggs hatched		Chicks fledged		Productivity (fledglings/ breeding pair)
				N	%	N	%	
1981	0	8	-	-	-	-	-	-
	1	6	6	5	83.3	5	100.0	0.83
	2	12	24	21	87.5	19	90.5	1.58
	Totals ¹	26	30	26	86.7	24	92.3	1.33
1982	0	6	-	-	-	-	-	-
	1	6	6	4	66.7	4	100.0	0.67
	2	23	46	42	91.3	33	78.6	1.43
	3	2	6	6	100.0	5	83.3	2.50
	Total ¹	31	58	52	89.6	42	80.8	1.35
1983	0	10	-	-	-	-	-	-
	1	4	4	2	50.0	0	0	0
	2	33	66	46	69.7	38	82.6	1.15
	3	5	15	13	86.7	9	69.2	1.80
	Totals ¹	42	85	61	71.8	47	77.0	1.12
1984 (2-15 July)	0	52	0	-	-	-	-	-
	1	4	4	?	?	?	?	-
	2	2	4	?	?	?	?	?
	Totals ¹	6	8	?	?	?	?	(0.14) ²
1985 (3-15 July)	0	55	0	-	-	-	-	-
	1	3	3	0	0	0	0	0
	2	0	0	-	-	-	-	-
	Totals ¹	3	3	0	0	0	0	0

¹Totals for pairs of nest-site holders that laid at least one egg.

²Eight eggs still present when observations ceased on 15 July; maximum productivity possible was 1.33 fledglings/ breeding pair.

marinus, near kittiwake nests. In that year, however, a single Short-tailed Weasel, *Mustela erminea*, was on GC4, and although the majority of nests appeared to be inaccessible it is possible that the weasel was responsible for the egg-loss. We were unable to measure breeding success in 1984 or 1985, but as the proportion of pairs that apparently laid was low, productivity was likely low in those years also.

We did not measure breeding success at Outer Gannet Island, but the following observation may be relevant. In 1983 Outer Gannet was visited on 23 July. We checked the contents of 57 nests; 55 were empty, one had two eggs, and the other had a single newly hatched chick. On the same date most nests on the Gannet Islands had large chicks. The reason for the delayed breeding and very low productivity on Outer Gannet in 1983 is not known. Nest contents were not examined at Outer Gannet in 1984 or 1985.

Kittiwake chicks on GC4 fledged after about 39 days each year in 1981-1983. First fledging was recorded on 18, 16 and 9 August in 1981 to 1983, respectively, and all chicks had fledged by the first week in September each year.

Discussion

The only other study of Black-legged Kittiwake breeding performance in low arctic waters of eastern North America was by Maunder and Threlfall (1972) at Witless Bay, Newfoundland, 800 km south of the Gannet Islands. It is difficult to make meaningful comparisons between these studies because observations were made in different years, and breeding parameters can vary markedly between years (Coulson and Thomas 1985). The timing of breeding was, not unexpectedly, earlier by about two weeks in Newfoundland (mean laying date: 3 June and 29 May in 1969 and 1970, respectively). Mean clutch sizes were similar:

1.9 at the Gannet Islands (in 1981-1983) and 1.85 in Witless Bay. However, there was a slightly higher proportion of 3-egg clutches in Labrador (7 of 93) than in Witless Bay (4 of 225), a difference that is statistically significant ($\chi^2 = 4.91$, 1 d.f., $P < 0.05$). Inter-egg laying intervals, incubation and chick-rearing periods were similar between the two colonies. Maunder and Threlfall (1972) found egg mortality to be 28% and 27% in two years (1969, 1970), whereas in this study it was 13%, 10% and 28% in three years (1981-1983). Chick mortality was similar in both colonies, Witless Bay: 19% and 26% in the two years, and in Labrador: 21%, 19% and 23% in the three years. In Witless Bay the mean number of chicks fledged per nest was 1.07 and 1.0 in two years, compared with 1.33, 1.35 and 1.12 in 1981 to 1983 in Labrador. As the percentage chick mortality was similar at both colonies, the difference in breeding success and overall productivity is due to the higher egg mortality in Witless Bay. This in turn may be due to different study techniques; Maunder and Threlfall (1972) inspected nests by visiting them, whereas our technique involved observations from a distance and thus no (detectable) human disturbance.

The most noticeable difference apparent between Maunder and Threlfall's (1972) study and ours was the almost total reproductive failure, or lack of breeding at the Gannet Islands in 1984 and 1985 (and at Outer Gannet in 1983). In 1985, failure to breed also was noted at colonies in Newfoundland, with about 20% non-breeding in Witless Bay (D. N. Nettleship, unpublished). There are no such data from Newfoundland in 1984. It seems likely that low productivity was not restricted to the Gannet Islands in 1985 (and 1984). Hunt et al. (1981) recorded similar phenomena at several Black-legged Kittiwake colonies in Alaska during the 1970s, and Springer et al. (1984) attributed such effects to a reduction in food availability associated with late ice break-up and low temperatures. As ice break-up was late in eastern Newfoundland and Labrador in both 1984 and 1985, the same explanation is plausible there.

The kittiwake population of Outer Gannet Island and the Gannet Islands increased rapidly, from 16 pairs in 1972 to 119 pairs in 1984. Studies of kittiwakes elsewhere indicate that such rapid colony growth, typical of small colonies (Coulson 1983), occurs mainly through immigration, rather than through the colony's own reproductive output (Porter 1985). Nonetheless, breeding performance of kittiwakes at the Gannet Islands, at least during 1981 to 1983, was similar, or relatively high, compared with other studies (e.g.,

Coulson and White 1958; Barrett and Runde 1980; Galbraith 1983; Coulson and Thomas 1985).

Kittiwakes have long been known to occur as non-breeding summer visitors along the Labrador coast (see Nettleship and Lock 1974), and we saw flocks totalling tens of thousands of birds on several occasions during August. There are several possible explanations for why kittiwakes should recently have started to breed in Labrador. First, Labrador may be an "overflow", either for the high arctic, or for the Newfoundland and Gulf of St. Lawrence populations. The status of kittiwake populations in the eastern Canadian arctic is unknown (Nettleship 1977), but populations in the southern part of their range (Newfoundland and the Gulf of St. Lawrence) have increased markedly during the last 30 to 40 years (Nettleship 1977, 1980). "Overflow" from this area therefore seems plausible, and the expansion into Labrador may simply be part of the increase in this population.

Another related possibility is that a change in the marine environment may have resulted in Labrador only recently providing suitable breeding conditions for kittiwakes. Further evidence for some sort of marine habitat change is the recent colonization of Labrador and eastern Newfoundland by Northern Fulmars, *Fulmarus glacialis*, (Nettleship and Lock 1973; Nettleship and Mongomerie 1974; Montevecchi et al. 1978); and Manx Shearwaters, *Puffinus puffinus*, (Storey and Lien 1985), both surface-feeding species with diets similar to Black-legged Kittiwakes.

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Winter and Early Spring Habitat Use by Snowshoe Hares, *Lepus americanus*, in South-central Alaska

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Snowshoe Hare, *Lepus americanus*, use was examined for 23 plant communities at differing elevation, aspect, and degree of slope on the north and south sides of the Susitna river in south-central Alaska. Based on fecal pellet occurrence, hares preferred White Spruce (*Picea glauca*) forest, alder (*Alnus* spp.) and willow (*Salix* spp.) plant communities, on slopes of 8 to >30°, at elevations from 630 to 750 m, with an eastern, southern, or southeastern aspect. Hare pellets consisted primarily of spruce, willow, and Labrador Tea (*Ledum groenlandicum*) fragments.

Key Words: Snowshoe Hares, *Lepus americanus*, habitat, foods, Alaska.

Snowshoe Hares, *Lepus americanus*, are the only leporid in the taiga of Alaska, and their importance in that ecosystem has been recognized. Cyclic-like fluctuations in hare populations can be dramatic, with densities ranging from highs of 800-1200 hares/km² to lows of 50/km² (Keith 1974). Wolff (1980) reported values of about 6 hares/ha at a population high, to < 1/ha at a population low in interior Alaska. During population highs hares are a major food source for Lynx, *Lynx canadensis*, and are also eaten by canids, mustelids, and raptors. At high populations, hares deplete their winter food resources (Wolff and Zasada 1979; Wolff 1980), which are sometimes shared with other herbivores (Wolff 1982).

Habitat use by Snowshoe Hares in Alaska has been evaluated only in the interior (O'Farrell 1965; Wolff 1980). Wolff (1980) investigated hare use of a mature Black Spruce (*Picea mariana*) forest, a burned Black Spruce stand, willow-alder (*Salix-Alnus*) thickets, and an open willow stand. Other studies examining habitat use by Snowshoe Hares in areas with similar plant communities were those of Grange (1932), Bider (1961), Keith (1966), Conroy et al. (1979), and Pietz and Tester (1983).

Hare abundance influences habitat use (Keith 1966; Wolff 1980; Pietz and Tester 1983). Wolff (1980) found that hares exhibited seasonal differences in habitat use and that occupancy of open habitats increased with increasing hare density. Open habitats are of poor quality for Snowshoe Hares because of greater exposure to predation and less food (Keith 1966; Wolff 1980; Pietz and Tester 1983; Sievert and Keith 1985).

Recently, Van Horne (1983) pointed out that evaluation of habitat preference of small mammals based only on abundance estimates during periods of high populations can be misleading. She cited examples of studies that found suboptimal habitat temporarily holding greater numbers of individuals than optimal habitat during population highs. Factors that contribute to this condition are seasonal habitat use, temporal unpredictability of the environment, habitat patchiness, social dominance interactions, high reproductive capacity of the species, and species that are habitat generalists (Van Horne 1983).

At least four of these factors apply to Snowshoe Hares in Alaska. Hares use certain habitats seasonally, the habitat can be extremely patchy, hares have a high reproductive capacity, and they appear to be habitat generalists. Thus, studies of habitat use by Snowshoe Hares are prone to the errors described by Van Horne (1983). However, these problems can be avoided by studying habitat use by hares during a single season when populations are at low levels and the habitats are not saturated.

This paper reports on habitat use by Snowshoe Hares in winter-early spring during a population low. It also examines the applicability of Wolff's (1978, 1980) results to an area of Alaska with greater habitat diversity.

Study Area

Our study area was located in the middle Susitna River basin, near the confluence of the Oshetna and Susitna rivers in south-central Alaska. The

broad, U-shaped glacial basin is generally oriented in an east-west direction between the Alaska Range to the north and the Talkeetna mountains to the south. Elevation ranged from about 330 m at the lowest portion of the river to over 2000 m on the mountain peaks. The wide range of environmental conditions in the basin has resulted in a complex mosaic of plant communities. Plant community composition and physiognomy have been strongly influenced by fire history, topography, soil moisture, aspect, and browsing by large herbivores. Precipitation in the basin averages about 51 cm and most of it falls during the frost-free period. Snow depths vary depending on site conditions. Wind-blown ridges can be free of snow, but drifts can exceed 3 m in thickness. Sixty to 75 cm was about the average snow thickness in most areas.

Snowshoe Hares were extremely rare in the middle basin at the time of study. Hare sign and sightings were essentially non-existent except in a relatively small area near the confluence of the Oshetna and Susitna rivers. Based on this fact, we concluded that hares were at a population low in the middle Susitna River basin.

Methods

Habitat use by Snowshoe Hares was evaluated along four transects. Each transect was 1 km in length. Transects were paired and paralleled each other; there were two on the north side and two on the south side of the Susitna River. The paired transects ran perpendicular to the river and were approximately 100 m apart. All four transects began in the basin above the river channel and extended to the river's high water mark. At the high water mark of the river, the paired transects ran parallel to the river bank in established vegetation, in opposite directions for approximately 100 m. The transects went through many different plant communities at different elevations, slopes, and aspects. Transects were surveyed twice between 15 May and 1 June 1983. On 15 May there were still patches of snow along all transects. By 1 June snow patches were confined to areas of northern aspect.

Each transect was examined by a different observer each time. At 10-m intervals along each transect (5-m intervals along the river), the observer stopped and recorded the plant community that dominated the immediate area. Plant communities were classified to level four of Viereck and Dyrness (1980) system — 1982 revision. Their classification system is hierarchical with five levels. Level one separates forest, scrub

(dwarf trees-shrubs), and herbaceous communities. Level two distinguishes between needleleaf and broadleaf forest, low and tall shrub, etc. Level three further divides forest communities into woodland (10-24% tree cover), open (25-59% cover), and closed ($\geq 60\%$ cover); a closed shrub community has $> 75\%$ cover, and an open shrub community from 25-74% cover. Level four of the system generally takes into account the dominant species, e.g. closed White Spruce (*Picea glauca*), open low willow, etc.

The elevation at each stop was estimated to the nearest 30 m with a pocket altimeter calibrated each day. Degree of slope was estimated with a clinometer in seven classes ranging from 0 to 30°. Aspect was estimated to the nearest of 8 divisions of the compass.

The observer also noted the presence or absence of Snowshoe Hare fecal pellets within a five meter radius of each stop; this provided an index to habitat use (Keith 1966; Wolff 1980; Pietz and Tester 1983; Litvaitis et al. 1985a). Hare pellets were collected from areas between stops during the first run of the transects and then from the stops during the second examination. Up to five pellets were collected at each stop where present.

Snowshoe Hare fecal pellets were used to estimate food habits. Only pellets that were intact and lying on top of the snow, litter, or moss layer were collected. This sample included older pellets from the previous seven months as well as fresh pellets. The pellets were pooled by transect and ground through a Wiley mill fitted with a 1-mm mesh screen. The ground material for each transect was thoroughly mixed and a random sample made into five microscope slides. Twenty fields per slide were examined at 100x magnification, and botanical composition of the slides was determined as described by Sparks and Malecheck (1968).

Habitat data were quantitatively expressed as a percentage of stops in each plant community, elevation, slope class, and aspect. Stops where hare pellets were present were quantified in the same manner with regard to plant community, elevation, slope, and aspect. Habitat and food habits data were averaged over transect pairs for the north and south sides of the Susitna River.

Chi-square goodness-of-fit tests were used to determine whether Snowshoe Hares used habitat in proportion to its availability with respect to plant community, elevation, slope, and aspect. Hare food habits were tested by species and category for differences between north and south sides of the river with *t*-tests. The categories tested

TABLE 1. Mean (SE) percentage of total stops and stops with Snowshoe Hare pellets in plant communities, elevation ranges, slope, and aspect along transects on north and south sides of the Susitna River.

Habitat Variable	Susitna River			
	North		South	
	Total	With Hares	Total	With Hares
Plant Community				
Forest				
closed White Spruce	2(2)	3(3)		
open White Spruce	14(9)	30(28)	5(1)	20(17)
woodland White Spruce	18(5)	11(0)	24(4)	10(1)
open Black Spruce	1(1)		3(1)	
woodland Black Spruce	9(6)			
open spruce-birch	2(2)	4(4)		
woodland spruce-birch	2(2)	1(1)		
Scrub-Shrub				
woodland Black Spruce	3(3)		1(1)	
closed alder	3(2)	8(1)	6(1)	32(17)
open alder	7(5)	17(9)	7(3)	28(28)
open Dwarf Birch			6(1)	
open low willow	14(3)	17(12)	10(2)	1(1)
open Dwarf Birch-willow	16(6)		16(6)	3(3)
open ericaceous shrub tundra	1(1)		3(0)	
open low alder	2(2)		15(1)	6(6)
open Paper Birch scrub	1(1)		1(1)	
open low Buffaloberry-cinquefoil		4(4)		
Elevation range (m)				
810-780	22(2)		14(1)	10(2)
779-750	27(3)	9(9)	6(1)	11(10)
749-720	7(3)	14(4)	14(2)	29(16)
719-690	9(1)	28(7)	18(2)	10(2)
689-660	12(1)	32(1)	9(1)	9(5)
659-630	12(6)	14(4)	29(3)	31(29)
629-600	11(5)	3(1)	10(3)	
Degree of slope				
0-1	10(8)		5(5)	2(2)
2-3	23(1)	4(1)	19(4)	5(5)
4-7	19(4)	2(2)	27(4)	8(8)
8-10	8(3)	30(10)	24(3)	61(30)
11-15	10(3)	25(17)	17(5)	10(2)
16-30	16(8)	13(13)	6(4)	14(14)
> 31	14(7)	26(18)	2(1)	
Aspect				
east	2(1)	2(2)	54(26)	69(30)
southeast	43(9)	65(18)	5(5)	
south	27(4)	22(11)	1(1)	
southwest	28(4)	11(11)	1(1)	
west			1(1)	
northwest			1(1)	
north			21(21)	25(25)
northeast			16(3)	6(6)
n = mean number of stops	171	21	216	24

were trees, shrubs, forbs, grasses, and cryptogams. A similarity index (Wolff 1978) and rank-order correlation were used to compare total diet

composition between opposite sides of the river. Statistical significance was accepted at $P \leq 0.05$ for all tests.

Results

Elevation of transects on both sides of the Susitna River ranged from 810 m to 600 m. (Table 1). Twenty three different plant communities were sampled; however, data from only 17 were used in the analysis.

Hare fecal pellets were present most often in White Spruce forest, alder stringers, and willow stands on both north and south transects (Table 1). A majority of hare pellets on the north transects were in open White Spruce, open alder, and open low willow communities. Along the south transects, stops with hare pellets were most often present in closed alder, open alder, and open White Spruce stands. Hares did not use plant communities in proportion to their availability on either north ($\chi^2 = 106$, $P < 0.001$) or south ($\chi^2 = 266$, $P < 0.001$) transects.

Hares preferred the steeper slopes ($\chi^2 = 128$, $P < 0.001$) and median elevations ($\chi^2 = 120$, $P < 0.001$) on the north and south (slope $\chi^2 = 120$, $P < 0.001$; elevation $\chi^2 = 35$, $P < 0.04$) sides of the river (Table 1).

The majority of stops along the north transects with hares were on southeast and south aspects

($\chi^2 = 22$, $P < 0.005$). On the south transects hares preferred east and north aspects ($\chi^2 = 19$, $P < 0.01$).

Snowshoe Hare fecal pellets contained primarily fragments from trees and shrubs (Table 2). The total number of individual pellets collected was 591 and 303 for north and south transects, respectively. On the north transects hare pellets contained 13% tree, 70% shrub, 9% forb, and 7% grass fragments. On the south transects trees were in 51% of the sample, shrubs, in 41%, forbs, in 6%, grasses, in 0.4% and cryptogams, in 0.4%. Spruce, willow, Labrador Tea (*Ledum groenlandicum*), and Dwarf Birch (*Betula glandulosa*) were the major forage species. Blueberry (*Vaccinium* spp.), horsetail (*Equisetum* spp.), and unidentifiable forbs and grasses were of lesser importance (Table 2).

Occurrence of spruce was significantly greater ($P < 0.005$) in fecal samples from the south side of the Susitna River. Frequency of occurrence of willows, American Red Raspberry (*Rubus idaeus*), alder, Dwarf Birch, and unidentifiable grasses were greater ($P < 0.05$) in samples from the north side. When forage species were included in categories only the frequency of occurrence of trees

TABLE 2. Mean (SE) percent relative density of plant fragments identified in Snowshoe Hare feces collected from north and south sides of the Susitna River.

Plant Species	Susitna River	
	North	South
Trees		
Spruce (<i>Picea</i> spp.)	13.4(2.9)	51.8(1.6)
Shrubs		
willow (<i>Salix</i> spp.)	30.7(3.7)	16.7(1.7)
Labrador Tea (<i>Ledum groenlandicum</i>)	20.8(7.0)	10.7(3.8)
Dwarf Birch (<i>Betula glandulosa</i>)	10.6(0.3)	6.9(0.4)
alder (<i>Alnus</i> spp.)	3.0(0.1)	1.9(0)
blueberry (<i>Vaccinium</i> spp.)	3.8(0.8)	3.4(0.3)
American Red Raspberry (<i>Rubus idaeus</i>)	0.9(0.9)	0.7(0)
Prickly Rose (<i>Rose acicularis</i>)	0.2(0.2)	1.1(0.3)
Forbs		
horsetail (<i>Equisetum</i> spp.)	5.6(0.6)	3.3(1.1)
Coltsfoot (<i>Petasites frigida</i>)	0.2(0.2)	0.4(0.4)
Bunchberry (<i>Cornus canadensis</i>)		0.2(0.2)
Unidentified forb	3.2(0.6)	2.5(0.4)
Grasses		
Holy Grass (<i>Hierochloa alpina</i>)	1.1(1.1)	
Bluejoint (<i>Calamagrostis canadensis</i>)	0.7(0.7)	
Fescue (<i>Festuca altaica</i>)	0.2(0.2)	
Unidentified graminoid	5.2(0.4)	0.4(0.1)
Moss	0.2(0.2)	
Lichen	0.2(0.2)	

($P < 0.005$) and cryptogams ($P < 0.05$) differed significantly between north and south transects. However, when evaluated as a whole, Snowshoe Hare diets were 91% similar and positively correlated ($r_s = 0.63$, $P < 0.01$).

Discussion

Snowshoe Hares used habitats disproportionately to their availability. Hares preferred White Spruce forest, alder, and willow communities with canopy covers from 25- > 75%. Hares avoided open plant communities such as woodland spruce forest, ericaceous shrub tundra, and low Buffaloberry (*Shepherdia canadensis*) — cinquefoil (*Potentilla* sp.). It should be kept in mind that open forest and scrub communities in Viereck and Dyrness (1980) classification system can have up to 59% and 75% cover of dominant species, respectively. Snowshoe Hares preferred dense forest and scrub plant communities when they were associated with the steeper slopes of the river channel, and eastern, and southeastern, or southern aspects. Most often spruce and scrub communities where Snowshoe Hares were present in this study had cover values near the upper limits of a category.

Snowshoe Hare fecal pellets were composed primarily of spruce and shrubs during winter-early spring on our study area. There were significant differences in the percentage of some forage species between north and south transects when evaluated individually. However, hare diets, based on all foods eaten, were 91% similar, indicating little difference between north and south sides of the river.

Wolff (1978) reported that Snowshoe Hares in interior Alaska consumed primarily spruce, willow, Labrador Tea, and alder in winter. Alder was not an important forage species in our study, although it was extremely abundant.

Habitat diversity of our study area was greater than that of Wolff's (1980). We sampled 23 plant communities, but only 11 were of major importance based on availability and use by Snowshoe Hares. Our results of diet and habitat use by hares during winter-early spring are very similar to those of Wolff (1978, 1980). This indicates that Snowshoe Hares have similar gross habitat requirements in interior and south-central Alaska during winter when populations are at low densities. Based on the results of other studies in Canada (Bider 1961; Keith 1966) and the north-central United States (Conroy et al. 1979; Grange 1932; Pietz and Tester 1983), hares appear to have similar gross habitat requirements throughout

their northern range. Keith (1966) and Wolff (1980) concluded that habitats occupied by Snowshoe Hares during population lows and/or winter are critical habitat. These habitats support remnant hare populations during periods of low density, and thus play a major role in preventing local extinctions and in providing a nucleus for subsequent population increases (Wolff 1980).

In our study area Snowshoe Hares also preferred areas of specific elevation, slope, and aspect. Undoubtedly, there is an interaction among these factors and the plant community that exists at a specific site. Few published studies have examined habitat use by hares with regard to elevation, slope, or aspect except at very gross levels. However, Litvaitis et al. (1985b) included visual estimates of slope and aspect in their study of hare habitat use in Maine. Contrary to our results, they reported that slope and aspect did not influence hare abundance. In our study, the large changes in elevation, slope, and aspect along the transect may have increased the importance of these factors relative to other studies. Although vegetation cover and density are the single most important factors influencing habitat use by hares, further investigation of topographical habitat components seems warranted.

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Viability and Germination of Herbaceous Perennial Species Native to Southern Alberta Grasslands

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The viability and germination of seed lots of 41 herbaceous perennial species native to southern Alberta grasslands were examined. The practical value of tetrazolium (TTC) and x-ray photography in screening seed lots for viability was evaluated. Although a reliable, rapid test for a few taxa, TTC often gave erratic results which were inconsistent with germination percentages and/or the physical condition of excised embryos. X-rays were useful for determining the percentage of full seeds in samples of species having large seeds, but had insufficient resolving power for samples of smaller seeds. Stratification improved germination in most species of Compositae, all three species of the Scrophulariaceae, and both species of Cactaceae. Scarification improved germination in 11 of 12 species of Leguminosae, and, in combination with stratification, improved germination of *Allium textile* (Prairie Onion) of the Liliaceae. Seeds of species in both Ranunculaceae and Rosaceae generally germinated as well with as without pre-treatment.

Key Words: viability, germination, herbaceous plants, perennials, tetrazolium, x-rays, Alberta, grasslands, Compositae, Scrophulariaceae, Cactaceae, Leguminosae, Ranunculaceae, Rosaceae.

Over 150 native, perennial, herbaceous species occur in undisturbed grasslands in Alberta. Many of these have potential for use in land restoration programmes in the province (Watson et al. 1980; Currah et al. 1983) but primarily due to the lack of information on their ecology and reproductive biology few have been considered for this purpose. As a first step in providing much needed data in these areas, this study was undertaken to examine the viability and germination of seeds collected from wild populations, and to observe the effects of standard pre-treatments on germination of seeds of 41 herbaceous perennial species native to Alberta's grasslands.

Materials and Methods

Seeds were collected from southern Alberta plants (nomenclature follows Packer 1983) in 1980, 1981, and 1982, dried at room temperature, and stored dry in paper envelopes at 3–6°C. Germination and viability tests were conducted in the spring and summer of the year following collection. Only apparently full seeds were used in viability and germination tests. Full seeds were selected by applying slight pressure to individual seeds with forceps. If there was resistance, seeds were considered full. Except where noted, germination tests done in 1981 consisted of four replicates of 25 seeds each. Tests in following years consisted of four replicates of 100 seeds each.

Two viability tests were used. The first involved soaking seeds in a 0.1% solution of 2,3,5-triphenyl tetrazolium chloride [TTC] (Grabe 1970) for up to 24 hours and examining embryos for evidence of dehydrogenase activity as indicated by the development of a red colour throughout the embryo. For the second viability test, x-ray photographs were prepared by placing seeds on Kodak X-OMAT TL film plates and exposing them to 25 kv for 7 seconds. Negatives were examined on a light table. Seeds were considered viable if the embryo appeared well formed and intact.

To obtain germination counts, seeds treated with a slurry of the fungicide Arasan 75 (1g/100ml), were sown on moist filter paper in petri dishes and placed in germination cabinets at 22°C in the dark for 30 days. Dishes were examined daily for germinated seeds, which were counted and removed. During the counting, seeds were exposed to normal room light. Water was replenished as necessary. Seeds were considered germinated once the radicle had emerged through the seed coat.

Pre-treatments included one or more of the following: stratification, mechanical scarification, acid scarification, alternating temperatures, and water-soaking. Seeds were stratified by moist cold (1 to 6°C) storage for 2–3 months in the dark. Mechanical scarification was achieved by abrading the seed coats with sandpaper (GR = 80 or 100) until scratches could be seen on the coat surface

under 40X magnification. A file was used to abrade seed coats of *Opuntia polyacantha* (Prickly Pear). For acid scarification, seeds were soaked in either concentrated H_2SO_4 or HCl for approximately 45 minutes (the time necessary to cause the breakdown of the seed coat in H_2SO_4) and then washed for several hours with running water. Hot-water soaking involved placing seeds in water heated to 80°C and allowing them to gradually cool there for 24 hours at room temperature. This treatment is used to soften seed coats to allow water uptake and radicle penetration, and/or to leach inhibitors from the seed or its coverings. Seeds incubated at alternating temperatures were held for 8 hours at 5°C and for 16 hours at 30°C for periods of three to six weeks. Viability and germination data were compared using analysis of variance and the F-test.

Results and Discussion

Neither of the two standard viability tests examined here (X-ray and TTC) gave results consistent with germination results for all species tested (Table 1).

The usefulness of x-ray examination was limited to larger seeds, since very small seeds (e.g. *Heuchera richardsonii* (Alum-root) and *Coryphantha vivipara* (Ball Cactus) were beyond the resolution capabilities of the x-ray machine. For larger seeds (e.g. *Opuntia polyacantha* and *Thermopsis rhombifolia* (Golden Bean), x-rays were useful in detecting shrivelled or damaged embryos (Figures 1-2).

The reliability of TTC tests was questioned when apparently healthy embryos stained incompletely (Figures 3-4). These observations support the conclusion reached by Justice (1972) that TTC is unacceptable as a universal test for viability.

In this study, we were only able to validate the effectiveness of viability tests when actual germination was similar to, or exceeded, percentages predicted by the viability tests. When fewer seeds germinated than predicted by viability tests, we could only conclude that dormancy was not overcome by the conditions provided. High viability and low germination percentages were obtained with *Coryphantha vivipara*, *Glycyrrhiza lepidota* (Wild Licorice), *Grindelia squarrosa* (Gumweed), and *Opuntia polyacantha*. Pre-treatments required to enhance germination of seeds collected from wild populations can be highly variable, either within a single seed lot (from one population), or among different seed lots (from different populations) [Crocker and Barton 1953]. Some consistent trends in pre-treatments required for germination did occur within some of

the families. The following discussion is restricted to those families for which two or more species were examined. Table 2 summarizes pre-treatment and germination results for all taxa examined.

Dormancy in legumes is generally maintained by the sclerified nature of the cells comprising the palisade layer of the seed coat (Crocker and Barton 1953; Barton 1965b; Villiers 1972; Rolston 1978; Werker 1980/81), and disruption of this layer is apparently necessary for germination (Brant et al. 1971). With the exception of *Glycyrrhiza lepidota*, scarification increased germination and/or decreased the time required for germination to occur. The effects of stratification varied from being detrimental in seed lots of *Glycyrrhiza lepidota*, *Hedysarum alpinum* (American Sweet-broom) and some seed lots of *Astragalus pectinatus* (Narrow-leaved Milk Vetch), to having no appreciable effect on *Astragalus bisulcatus* (Two-grooved Milk Vetch), *A. crassicaarpus* (Buffalo Bean), *A. drummondii* (Drummond's Milk Vetch), and *Petalostemon purpureum* (Purple Prairie Clover), to being beneficial in some seed lots of *Astragalus striatus* (Ascending Purple Milk Vetch), *Oxytropis monticola* (Yellow Loco-weed), and *O. sericea* (Early Yellow Loco-weed).

Most seed lots of Compositae (except *Senecio canus* (Prairie Groundsel) and one seed lot of *Antennaria nitida* (Pussy-toes) had increased germination percentages or decreased time for germination after stratification. Seed lots generally varied in their degree of response to stratification (e.g. *Gaillardia aristata* (Gaillardia), *Grindelia squarrosa*, *Heterotheca villosa* (Golden Aster), and *Liatris punctata* (Blazing Star) (Table 2). These variations might be attributable to conditions under which seeds were formed (Barton 1965a, Austin 1972).

In the Rosaceae, *Geum* (Avens) species demonstrated consistently high germination percentages and apparently required no pre-treatment. Some dormancy was present in some seed lots of *G. triflorum* (Prairie Smoke), since a decrease in the time required for germination was observed following stratification. Sorensen and Holden (1974) also found that pre-treatments were not necessary for *Geum triflorum* seeds collected in South Dakota. These observations do not agree with those made with other rosaceous seeds (of different sub-families) which have been shown to require a long stratification period for germination (Mayer and Poljakoff-Mayber 1982).

Germination of species of Cactaceae varied according to the year in which seed lots were collected. *Coryphantha vivipara* seed lots collected

TABLE 1. Percent viability as determined by TTC and x-rays in a selection of seed lots of species native to Alberta's grasslands.

Taxa	X-ray (%)	TTC (%)	Maximum Observed Germination (%)
<i>Achillea millefolium</i>	93	99	96
<i>Allium textile</i>	97	99	82
<i>Anemone cylindrica</i>	92	94	100
<i>Anemone multifida</i>	95	95	93
<i>Antennaria nitida</i>	98	97	100
<i>Arnica fulgens</i>	95	96	100
<i>Astragalus bisulcatus</i>	96	94	98
<i>Astragalus drummondii</i>	—	89	65
<i>Astragalus gilviflorus</i>	100	97	96
<i>Astragalus pectinatus</i>	96	99	100
<i>Astragalus striatus</i>	100	100	100
<i>Besseyia wyomingensis</i>	—	78	91
<i>Coryphantha vivipara</i>	—	100	92
<i>Eriogonum flavum</i>	89	96	98
<i>Gaillardia aristata</i>	74	79	96
<i>Geum aleppicum</i>	100	99	100
<i>Geum triflorum</i>	99	98	100
<i>Glycyrrhiza lepidota</i>	81	87	47
<i>Grindelia squarrosa</i>	98	99	73
<i>Haplopappus spinulosus</i>	83	94	98
<i>Hedysarum alpinum</i>	99	99	100
<i>Heterotheca villosa</i>	92	92	100
<i>Heuchera richardsonii</i>	—	98	93
<i>Hymenoxys richardsonii</i>	96	89	100
<i>Liatris punctata</i>	96	99	100
<i>Linum lewisii</i>	99	99	100
<i>Monarda fistulosa</i>	95	93	100
<i>Opuntia polyacantha</i>	98	98	49
<i>Oxytropis monticola</i>	99	99	100
<i>Oxytropis sericea</i>	100	98	99
<i>Penstemon nitidus</i>	95	90	62
<i>Penstemon procerus</i>	98	93	69
<i>Petalostemon purpureum</i>	98	98	97
<i>Solidago rigida</i>	79	73	92
<i>Thermopsis rhombifolia</i>	95	95	88

— no data available

from the same site over a three year period responded differently to stratification according to the year of collection. In *Opuntia polyacantha*, scarification (acid or mechanical) did not affect germination, but some improvement was observed following stratification. A period of alternating temperatures was partially effective in promoting germination in this taxon but satisfactory germination percentages were never obtained in the laboratory even though viability tests indicated that 98% of seeds in a given seed lot were viable.

In the Scrophulariaceae, some variation from year to year was observed in the germination of

Penstemon (Beard-tongue) species. Both *Penstemon procerus* (Slender Blue Beard-tongue) and *P. nitidus* (Smooth Blue Beard-tongue) germinated better following several months of cold stratification, but neither species had germination percentages above 65%. Highest germination percentages for *Besseyia wyomingensis* (Kitten-tails) were obtained following two to three months stratification.

Each of the three species examined in the Liliaceae reacted differently to pre-treatments. Non-stratified seeds of *Yucca glauca* (Soapweed) germinated as well as stratified seeds. *Smilacina*

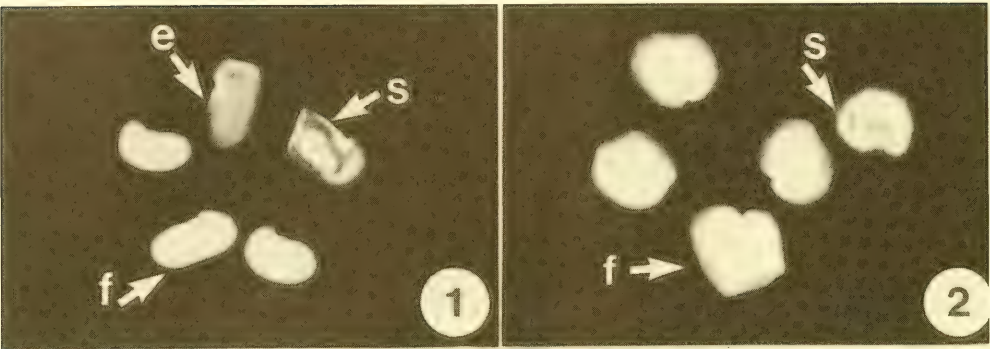


TABLE 2. Effects of certain pre-treatments on seed lots of native, herbaceous perennials. (st — stratification, sc — acid or mechanical scarification, sk — soaking).

FAMILY/Species	Range of Germination Values Among Seed Lots for Untreated Seeds (%)	Range of Germination Values Among Seed Lots for Treated Seeds (%)		Comments
CACTACEAE				
<i>Coryphantha vivipara</i>	0-80	st	0-92	Significant variation in germination among seed lots.
<i>Opuntia polyacantha</i>	0-2	st 2mo st 3mo sc sc HCl sc H ₂ SO ₄ sk	0-49 1-45 0-4 0-5 0 0	
COMPOSITAE				
<i>Achillea millefolium</i>	16-50	st	59-96	Response to stratifica- tion varied among seed lots.
<i>Antennaria nitida</i>	8-100	st	83-96	
<i>Arnica fulgens</i>	59-85	st	79-100	Stratification increased germination signifi- cantly in one seed lot.
<i>Gaillardia aristata</i>	32-96	st	36-93	
<i>Grindelia squarrosa</i>	4-15	st	0-73	Stratification decreased time for germination.
<i>Haplopappus spinulosus</i>	78-90	st	91-98	
<i>Helianthus subrhomboideus</i>	0	st	48-59	
<i>Heterotheca villosa</i>	84-100	st	84-100	
<i>Hymenoxys richardsonii</i>	49-96	st	79-100	
<i>Liatris punctata</i>	74-100	st	92-100	Stratification increased germination signifi- cantly in one seed lot.
<i>Senecio canus</i>	79-86	st	69-75	Stratification decreased time for germination.
<i>Solidago rigida</i>	22-92	st	65-92	
LABIATAE				
<i>Monarda fistulosa</i>	68-92	st	70-100	
LEGUMINOSAE				
<i>Astragalus bisulcatus</i>	0-30	st sc sc/st sk	20-35 64-98 89-91 32-44	
<i>Astragalus crassicaarpus</i>	8-14	st sc sc/st	6-15 97-100 77-83	

(Continued)

- FIGURE 1. X-ray photograph of *Thermopsis rhombifolia* seeds showing full seed (f), empty seed (e), and a shrivelled embryo (s). X1.8.
- FIGURE 2. X-ray photograph of *Opuntia polyacantha* seeds showing full seed (f) and a shrivelled embryo (s). X2.1.
- FIGURE 3. Viable embryos of *Hedysarum alpinum* stained with TTC showing differential staining reaction: (a) completely stained embryo, (b) partially stained embryo, and (c) unstained embryo). X2.5.
- FIGURE 4. Viable embryos of *Liatris punctata* stained with TTC showing differential staining reaction (a) completely stained embryo, (b) partially stained embryo, and (c) unstained embryo). X2.5.

TABLE 2. (Continued). Effects of certain pre-treatments on seed lots of native, herbaceous perennials. (continued) (st — stratification, sc — acid or mechanical scarification, sk — soaking).

FAMILY/Species	Range of Germination Values Among Seed Lots for Untreated Seeds (%)	Range of Germination Values Among Seed Lots for Treated Seeds (%)		Comments
<i>Astragalus drummondii</i>	2-6	st	5-9	Less than 2% of the seeds collected in 1982 germinated.
		sc	41-65	
		sc/st	33-44	
<i>Astragalus gilviflorus</i>	25-40	sc	88-96	
<i>Astragalus pectinatus</i>	15-40	st	5-10	
		sc	72-99	
		sc/st	82-98	Scarification generally decreased the time for germination.
		sk	56-100	
<i>Astragalus striatus</i>	7-30	st	1-21	
		sc	77-100	
		sc/st	75-91	
		sk	32-52	
<i>Glycyrrhiza lepidota</i>	19-47	st	0-3	
		sc	5-17	
		sc/st	4-18	
<i>Hedysarum alpinum</i>	88-100	st	60-91	
		sc	82-100	
		sc/st	58-95	
		sk	60-88	
<i>Oxytropis monticola</i>	3-24	st	6-50	
		sc	64-100	
		st/sc	81-99	
		sk	32-48	
<i>Oxytropis sericea</i>	9-23	st	7-40	
		sc	90-99	
		sc/st	73-92	
<i>Petalostemon purpureum</i>	45-54	st	44-57	
		sc	95-97	
		sc/st	30-70	
<i>Thermopsis rhombifolia</i>	2-12	st	5-19	
		sc	26-88	
		sc/st	30-79	
		sk	4-12	
LILIACEAE				
<i>Allium textile</i>	3-8	st	16-31	
		sc	4-72	
		sc/st	27-82	Stratification decreased time for germination.
<i>Smilacina stellata</i>	0-66	st	10-89	
<i>Yucca glauca</i>	76-92	st	81-92	
LINACEAE				
<i>Linum lewisii</i>	60-94	st	73-100	
POLYGONACEAE				
<i>Eriogonum flavum</i>	29-88	st	37-98	
PRIMULACEAE				
<i>Dodecatheon conjugens</i>	0-4	st	0-36	
		sc	0-2	
RANUNCULACEAE				
<i>Anemone cylindrica</i>	58-100	st	60-87	No significant difference between stratified and non-stratified seeds.
<i>Anemone multifida</i>	4-93	st	74-92	

(Continued)

TABLE 2. (Concluded). Effects of certain pre-treatments on seed lots of native, herbaceous perennials. (continued) (st — stratification, sc — acid or mechanical scarification, sk — soaking).

FAMILY/Species	Range of Germination Values Among Seed Lots for Untreated Seeds (%)	Range of Germination Values Among Seed Lots for Treated Seeds (%)		Comments
ROSACEAE				
<i>Geum aleppicum</i>	99-100	st	100	
<i>Geum triflorum</i>	95-100	st	88-100	Stratification some- times decreased time for germination.
SAXIFRAGACEAE				
<i>Heuchera richardsonii</i>	8-93	st	1-31	
SCROPHULARIACEAE				
<i>Besseyia wyomingensis</i>	0-5	st 2mo	0-91	
		st 3mo	68-89	
		sk	0	
		sc	0-1	
<i>Pensstemon nitidus</i>	0-20	st 2mo	0-25	Stratification decreased time for germination.
		st 3mo	26-62	
		sk	0-2	
<i>Penstemon procerus</i>	4-52	st	10-69	Stratification decreased time for germination.

stellata (Star-flowered Solomon's-seal) germinated best following stratification. Since seeds were removed when the radicle emerged from the seed coat, it is unknown if this species has a double dormancy as has been reported in *Smilacina racemosa* (False Solomon's-seal) (Crocker and Barton 1953). *Allium textile* germinated best following stratification and scarification.

Clearly, there are a number of different dormancy mechanisms to consider in the seeds of the species examined. Our survey indicates that, in general, a single stratification period will break the endogenous dormancy of Compositae, whereas scarification alone is a suitable treatment to break exogenous dormancy in most species in the Leguminosae. There should be few problems in growing native species of these two families for use in land reclamation or habitat enhancement projects. The dormancy mechanism in hard to germinate seeds (e.g. *Opuntia polyacantha*, *Dodecatheon conjugens* (Shooting Star) and *Glycyrrhiza lepidota*) requires closer examination.

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Characteristics of Sharp-tailed Grouse, *Tympanuchus phasianellus*, Leks in the Parklands of Manitoba

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Characteristics of Sharp-tailed Grouse (*Tympanuchus phasianellus*) leks were studied in southwestern Manitoba from May 1983 through May 1985. Leks were situated an average of 2.2 km apart. Leks averaged 450 m² in size, with area per displaying male approximately 50 m². Leks were higher in elevation than most surrounding terrain within 500 m. Lek display areas were ≥ 0.5 m higher than display perimeters. Display areas were flat surfaces sloped $\leq 1\%$. Vegetation height was less on display areas than on perimeter areas at all times of the year. Ground cover consisted of grass (70%), forbs (15%), bare ground (15%), and shrubs ($\leq 1\%$). Visibility on display areas increased progressively from summer to fall to spring. Each lek had escape cover within 500 m and trees for perching within 400 m. Key environmental characteristics for Sharp-tailed Grouse leks are elevated sites with wide-viewing horizons and nearby female perching trees. These locations appear to maximize sound transmission for both sexes.

Key Words: Sharp-tailed Grouse, *Tympanuchus phasianellus*, lek, dancing ground, habitat measurement, Manitoba.

A dancing ground or lek is a communal display area where males congregate for the purpose of attracting and courting females, and to which females come for mating (Wilson 1975). Bradbury and Gibson (1983) described a lek mating system as one in which males contribute no parental care, male territories contain no limiting resources for females, females select a mate, and a mating arena exists.

Several studies have provided qualitative descriptions of Sharp-tailed Grouse, *Tympanuchus phasianellus* dancing grounds. Baumgartner (1939) described leks as open, grassy knolls or ridges, usually with sparse vegetation. Grange (1948) and Ammann (1957), reporting on display grounds in Wisconsin and Michigan, respectively, suggested that relatively open, elevated sites having low or sparse vegetation were preferred. Hart et al. (1950) found that most leks used by sharptails in Utah were on small knolls or high hills, in a weed-grass cover type. In Saskatchewan and Idaho, respectively, Pepper (1972) and Ward (1984) found that unhindered visibility was characteristic of display sites. Kobriger (1965), Twedt (1974), and Sisson (1976) provided quantitative descriptions of some Sharp-tailed Grouse lek components in Nebraska studies.

In this paper, I provide a comprehensive, quantitative description of the environmental components which constituted Sharp-tailed Grouse leks in the aspen parkland of southwestern Manitoba.

Study Area and Methods

The study was conducted in the Carberry Sand Hills, southwestern Manitoba, approximately 160 km west of Winnipeg. The area derives its name from a deltaic deposit of sand formed where the ancient Assiniboine River system emptied into glacial Lake Agassiz. Surficial deposits range from approximately 3 to 120 m, with topography nearly level to gently undulating. Average annual precipitation is 48 ± 3 cm, with about 70% occurring as rain. Part of the study area included Canadian Forces Base Shilo, an active military training range, where vehicular disturbance and occasional wildfires occurred.

The study area was aspen parkland vegetation type, consisting of Trembling Aspen (*Populus tremuloides*) thickets interspersed with open prairie grassland. Major grasses included Blue Grama (*Bouteloua gracilis*), Prairie Junegrass (*Koeleria cristata*) and Porcupine Needlegrass (*Stipa spartea*). Predominant forbs included sages (*Artemisia frigida*, *A. campestris*, *A. ludoviciana*), Three-flowered Avens (*Geum triflorum*), Field Horsetail (*Equisetum arvense*), Leafy Spurge (*Euphorbia esula*) and Black-eyed Susan (*Rudbeckia hirta*). Shrubs were Prickly Rose (*Rosa acicularis*), Creeping Juniper (*Juniperus horizontalis*), willows (*Salix* spp.), Common Snowberry (*Symphoricarpos albus*) and Poison Ivy (*Toxicodendron radicans*).

The study area was searched systematically for leks during spring 1983 and 1984 (Baydack 1986). I verified locations by walking to the designated site

and observing grouse and/or evidence of display activity, i.e. trampled vegetation, droppings, and/or feathers.

Lek locations were plotted on 1:50 000 National Topographic Service maps of the study area. Twelve leks were selected for investigation in locations where agricultural influences would be minimized. Ten of the twelve study leks were active during the entire investigation. The remaining two were not used by sharptails after spring 1983; therefore, data from these two inactive leks were analyzed separately. Site characteristics were measured in spring (April - May), summer (June - August), and fall (September - November) 1983 and 1984.

Lek areas and general shapes were determined by eight evenly-spaced measurements from lek centre to edge. Lek centre, usually the most heavily trampled location on the lek, was determined by observing grouse activity. Lek edge was defined as the first 5-m distance along a transect from lek centre where visual evidence of display activity was no longer apparent. Four transect lines, oriented along and perpendicular to the longest axis, were staked from lek centre to edge (display area), and to a point 50 m beyond lek edge (display perimeter). Sampling points were at 5-m intervals along each transect. Elevation, vegetation height, ground cover and visibility were recorded at each sampling point, and were compared for each lek between display areas and display perimeters using a *t*-test.

Elevation was recorded using a surveyor's level and rod. Lek slope was derived using a best-fit, linear, unbiased regression plot. Elevation was also measured at all points ≤ 500 m from each lek which appeared to be higher than lek centre.

Maximum vegetation height was measured in dm using a surveyor's rod. Ground cover (percent of shrubs, forbs, grasses, and bare ground) was measured using line-intercept (Canfield 1941) and 0.1-m² plots (Daubenmire 1959).

Visibility was measured at sampling points using the cover board technique (Jones 1968). In addition, visibility from lek centre was estimated along each transect. An observer at lek centre, lying at grouse-eye level (approximately 20 cm), indicated the highest point on a surveyor's rod where his vision was obstructed. This height was recorded at each sampling point and was used as an index of visibility from lek centre. A best-fit, linear, unbiased regression of visible height versus distance from lek centre was derived.

Distances to escape cover and advertising or perching trees were measured by pacing from each

lek centre. Appropriate locations were determined by observing grouse behaviour during summer and fall 1983 and spring 1984.

Results and Discussion

Spatial Distribution

Active leks were an average of 2.2 km apart over 87.5 km², representing a density of 0.1/km². Inactive leks A and B were closer than average to an active lek. Ammann (1957), Lumsden (1965) and Sisson (1976) found that spacing between sharptail leks ranged from 0.8 - 2.4 km. Lek distribution likely varies according to habitat type, habitat availability, and population density. The fact that the number of dancing grounds on a given area changes yearly as a result of population fluctuation (Lumsden 1965; Cannon and Knopf 1981) possibly explains the inactivity at formerly active leks A and B. Leks A and B may also have been transient or satellite locations.

Appropriate lek area varied from 100 to 1220 m², with mean size about 450 m². Lumsden (1965), Twedt (1974) and Sisson (1976) also noted that lek area was highly variable. Inactive leks A and B were larger than average, possibly indicative of changeable boundaries at transient locations.

Area per displaying male at the ten active leks was found to be 50 m², which is within the territory size range of 14 - 170 m² determined by Evans (1969) and Hjorth (1970) and is identical to the mean size reported by Hjorth (1970). If this mean territory size is found to be constant over North American Sharp-tailed Grouse range, population estimates might be derived from lek size measurements.

Leks were not oriented in a consistent compass direction, although oval-shaped, NW-to-SE orientations were most common. This characteristic is likely a result of study area topography.

Elevation

Lek elevations were generally higher than most surrounding terrain within 500 m. For individual leks, the number of sites within 500 m having higher elevation ranged from 2 to 9, with a mean of 4.7. Lek centres were ≥ 0.5 m higher than display perimeters of leks. Display areas were flat surfaces, and a best-fit, linear, unbiased regression estimate for lek slope was $-0.010 \pm .003$, indicating an approximate 1% drop in elevation over display areas.

The predominant descriptor of open country avian leks has been an elevated site (Hjorth 1970). These locations afford improved visibility and unrestricted movement, important to increased

TABLE 1. Mean of maximum vegetation heights (cm) for Sharp-tailed Grouse lek display area (DA) vs. display perimeters (DP), Carberry Sand Hills, Manitoba, 1983-84.

Lek number ¹	Summer (June-August) 1983			Fall (September-November) 1983			Spring (April-May) 1984		
	DA	<i>t</i> -test <i>P</i>	DP	DA	<i>t</i> -test <i>P</i>	DP	DA	<i>t</i> -test <i>P</i>	DP
1							9.7	0.07	16.2
2							11.4	0.08	19.6
3	35.3	0.02	46.0	38.2	0.04	48.5	13.3	0.05	21.8
4				32.1	0.08	39.8	8.3	0.06	17.9
5							8.1	0.06	16.7
6	41.1	0.01	64.4	35.8	0.01	86.7	14.3	0.04	23.1
7	34.2	0.02	45.5	38.3	0.03	49.6	11.8	0.09	16.9
8	27.0	0.32	29.9	24.5	0.05	31.0	10.6	0.04	17.1
9	41.4	0.06	46.6	40.3	0.02	48.6	7.9	0.03	17.7
10	30.9	0.03	45.5	34.1	0.71	35.8	8.1	0.03	17.4
Mean	35.0	0.04	46.3	34.8	0.03	48.6	10.4	0.08	18.4
A	33.1	0.09	39.1				11.9	0.18	16.7
B	26.7	0.64	28.3	24.0	0.91	24.3	14.3	0.84	16.6

¹Numerals refer to active leks; letters refer to inactive leks.

observability of mates and decreased predation (Hjorth 1970; Wiley 1974). Bradbury and Gibson (1983) indicated that environmental considerations are necessary to fully explain behavioural models (hotspots or large clumps of males) of determination of lek dispersion. I suggest that a critical environmental determinant for sharptails is an elevated location.

Study leks were relatively level, with < 1% decrease in elevation over the display area. Twedt (1974) and Sisson (1976) also found the slope on leks in Nebraska was gentle, usually $\leq 3.5\%$. A greater slope might increase visual obstruction, thus counteracting benefits of improved visibility afforded by increased elevation.

Vegetation Characteristics

Vegetation height on leks throughout the year was less on active display areas than on display perimeters (Table 1). Spring vegetation height on

display areas was less than at other times of the year, averaging 10.4 ± 1.1 cm.

Lower vegetation height on display areas, especially during spring, was primarily a result of grouse trampling. Other researchers noted similar results in Nebraska (Kobriger 1965; Sisson 1976). Twedt (1974) reported spring vegetation heights at dancing grounds in Nebraska at 8.5 cm, and Anderson (1969) indicated 12-15 cm for Greater Prairie-chickens (*T. cupido*) in Wisconsin. Hart et al. (1950) noted that leks in Utah were in the shortest cover type available.

Ground cover of display areas was composed of fewer shrubs and more bare ground than on display perimeters. Percent ground cover type did not vary ($P > 0.10$) among seasons (Table 2). Ground cover was dominated by grasses (70%), followed by approximately equal amounts of forbs and bare ground (15%), and a small amount of shrubs ($\leq 1\%$).

TABLE 2. Seasonal ground cover on Sharp-tailed Grouse lek display areas, Carberry Sand Hills, Manitoba, 1983-84.

Date ¹	<i>N</i> ²	Ground cover type (%)			
		Shrub	Forb	Grass	Bare ground
Summer 1983	98	1.0	19.1	67.7	12.2
Fall 1983	145	1.6	18.4	65.2	14.8
Spring 1984	183	0.8	15.3	68.0	15.9

¹Summer = June-August; Fall = September-November; Spring = April-May.

²Number of 0.1 m² plots (Daubenmire 1959).

TABLE 3. Mean % visibility¹ for Sharp-tailed Grouse display areas (DA) vs. display perimeters (DP), Carberry Sand Hills, Manitoba, 1983-84.

Lek number ²	Summer (June-August) 1983			Fall (September-November) 1983			Spring (April-May) 1984		
	DA	<i>t</i> -test <i>P</i>	DP	DA	<i>t</i> -test <i>P</i>	DP	DA	<i>t</i> -test <i>P</i>	DP
1							72.1	0.01	22.8
2							69.2	0.02	33.2
3	20.8	0.38	16.7	37.5	0.32	32.3	76.3	0.09	57.7
4				39.6	0.81	40.1	55.1	0.18	44.4
5							65.2	0.01	42.8
6	17.1	0.04	6.3	32.1	0.53	21.7	68.3	0.03	49.7
7	32.1	0.01	8.9				74.6	0.02	53.4
8	40.8	0.41	37.3	62.9	0.55	60.0	84.0	0.02	76.4
9	13.2	0.31	16.7	22.3	0.64	24.0	71.5	0.05	64.3
10	49.3	0.55	46.4	52.9	0.52	56.8	81.5	0.07	77.2
Mean	28.9	0.33	22.1	41.2	0.59	39.2	71.8	0.04	52.2
A	40.4	0.04	24.3				61.4	0.62	59.2
B	46.1	0.98	46.0	50.5	0.38	53.7	67.3	0.49	63.7

¹Percentage of 75 black and white squares on a cover board visible from grouse-eye level (20 cm) at 10-m distances from each sampling point (Jones 1968).

²Numerals refer to active leks, letters to inactive leks.

The prevalence of bare ground and absence of shrub cover on leks relative to surrounding areas likely improves grouse visibility. Whether sharp

tails select sites for leks because of cover composition or cause it through trampling (especially of shrubs) is unclear.

Visibility

Visibility on display areas increased progressively from summer (29%) to fall (41%) to spring (72%) (Table 3). Visibility on display areas was greater than on display perimeters in spring, but no different in summer or fall. Relatively high visibility on lek display areas during spring allows for improved observability of predators, mates, and other males. Reduced visibility due to vegetation growth occurs during summer and fall, periods of low or non-use. My results are similar to Ward's (1984) findings in Idaho that grouse preferred sites with 70-80% visibility during spring.

Visibility from lek centre was reduced progressively at greater distances along each transect. A best-fit, linear, unbiased regression showed that the height at which an object was obstructed from view from lek centre increased by approximately 12 cm with each 10-m progression from lek centre. The reduction of visibility with distance from lek centre may indicate that the observation range for central males on each lek is confined to a certain distance, leaving peripheral males to function as sentinels for predator observation.

Surrounding Cover

Distance to escape cover from study leks ranged from 200 to 3000 m. At all leks, suitable cover was present ≤ 500 m from lek centre. Although no

TABLE 4. Environmental characteristics of Sharp-tailed Grouse leks in the Carberry Sand Hills, Manitoba, 1983-84.

Component	Measurement
Next nearest lek	1.7 - 2.9 km, $\bar{X}$ = 2.2 km
Orientation	NW to SE
Area	100-1220 m ² , $\bar{X}$ = 446 m ²
Area/displaying male	50 m ² over display area
Surrounding terrain	Flat to undulating, ≥ 0.5 m lower elevation than lek centre
Slope	$\leq 1\%$ over display area
Vegetation height in spring	7 - 13 cm, $\bar{X}$ = 10.4 cm
Ground cover in spring	
shrub	$< 1\%$
forb	15%
grass	70%
bare ground	15%
Visibility	Unrestricted in all directions, 70-80% on display area.
Distance to escape cover	≤ 500 m
Distance to perching trees	≤ 400 m

specific distances were presented, Twedt (1974), Sisson (1976), and Ward (1984) noted the importance of nearby escape cover.

Distance to female advertising or perching sites from study leks ranged from 200 to 600 m and averaged 400 m. Perching sites were sometimes equidistant from two or more leks. These sites are, I believe, important determinants of lek location. Prior to being observed on leks in spring, female sharptails congregated during mornings in tall (6–10 m) aspen trees and “gobbled”. The gobble sound was audible on nearby leks and stimulated male dancing activity; however, only the male ‘coo’ and ‘chik’ notes from the dancing ground could be heard at perching trees.

All sounds audible to humans at the perching trees have been measured as low frequency sound waves (Kermott and Oring 1975; Sparling 1981). Given that the least attenuation occurs in grassland habitats for low frequency waves (Marten and Marler 1977), these sounds are likely serving a long-distance communication function. Since vocalizations are important to successful mating in all tetraonines and many other species, I hypothesize that sharptail leks may be located so as to maximize sound transmission, thereby optimizing mating opportunities for each sex. The presence of perching trees at a certain distance may contribute to the spatial distribution of leks, and may be an essential factor for females in selecting a lek and/or a male for mating.

The characteristics of Sharp-tailed Grouse leks which I have described quantitatively (Table 4) agree with the general, often qualitative, descriptions available. These data will be useful not only for species management, but also for better understanding of the lek mating system. Key environment factors for sharptail leks include elevated sites with wide-viewing horizons and nearby female advertising sites — locations which maximize sound transmission for both sexes. These environmental characteristics should be addressed as additional considerations to the behavioural models presented by Bradbury and Gibson (1983).

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8. *Aralia nudicaulis* L., Wild Sarsaparilla

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Aralia nudicaulis L. is a rhizomatous, perennial herb with a short, thick caudex which bears the above ground shoot. The shoot consists of a single compound leaf which, when reproductive, subtends a short scape which bears an umbellate inflorescence. The plant is dioecious and exhibits sexual dimorphism for several characteristics. *Aralia nudicaulis* is common in mesic forests from Newfoundland to British Columbia where it usually forms large clones in undisturbed communities. Flowering occurs in late May and early June and the fruit, a berry-like drupe, matures in early August. Although the plant is of no contemporary economic importance it has been used for medicinal purposes in the past.

Key Words: *Aralia nudicaulis* L., Wild Sarsaparilla, ecological life history, sexual dimorphism, clonal plant, botany.

1. Name

Aralia nudicaulis L.; Araliaceae.

Wild Sarsaparilla, Wild Ginseng (Turner 1975); Salseparielle (Marie-Victorin 1964).

The generic name is thought to be derived from the Indian name for the plant (Marie-Victorin 1964).

2. Description of the Mature Plant

(a) *Raunkiaer life-form*: Hemicryptophyte. Winter-deciduous, broad-leaved, clonal, perennial herb; reproduces by seeds and rhizomes, the latter long-lived and extensive. The plant behaves like an "underground or buried shrub"; unlike most true herbs, it has abscission layers for leaves and their leaflets.

(b) *Shoot morphology*: The above-ground portions of the *Aralia nudicaulis* shoot include only the twice-compound leaves and the fertile shoots, both of which develop from small, subterranean, or occasionally emergent, erect spur shoots which themselves are attached to the extensive underground rhizome system (Figure 1). The leaf blade is ternately, pinnately decompound, 3-6 dm long including the petiole, the primary divisions 3-5 foliolate, petiolulate, the petiolules up to 10 cm long (occasionally longer), the glabrous leaflets sessile or short-stalked (less than 2 cm), ovate to elliptic, unequally obtuse or acute at the base, acuminate at the apex, serrate, 3-6 cm long. The peduncle is erect, usually shorter than the petiole, commonly bearing 3 umbels.

(c) *Root morphology*: The extensive rhizome system, which occurs at a mean depth of 6 cm in the mineral soil (Flinn and Wein 1977), branches in a distichous pattern with each branch producing at its apex an erect 'spur shoot' or caudex (Figure 1). The caudex produces both leaves and flowering shoots, but individual caudices are not necessarily active every season. True roots are adventitious and develop from the nodes on the rhizome. Secretory canals may be found in the pith, phloem and cortex of both stem and root tissue (Graham 1966).

(d) *Inflorescence*: The umbels of the inflorescence contain numerous 5-6 merous, epigynous, functionally unisexual flowers. The pedicels are 5-15 mm long, the calyx is approximately 2 mm long at maturity with minute sepal-like lobes; the greenish-white petals are 1.5-3.0 mm long; stamens and styles are distinct; the fruit is a fleshy, 5-loculed, berry-like drupe, 3-6 cm in diameter, purplish-black when mature.

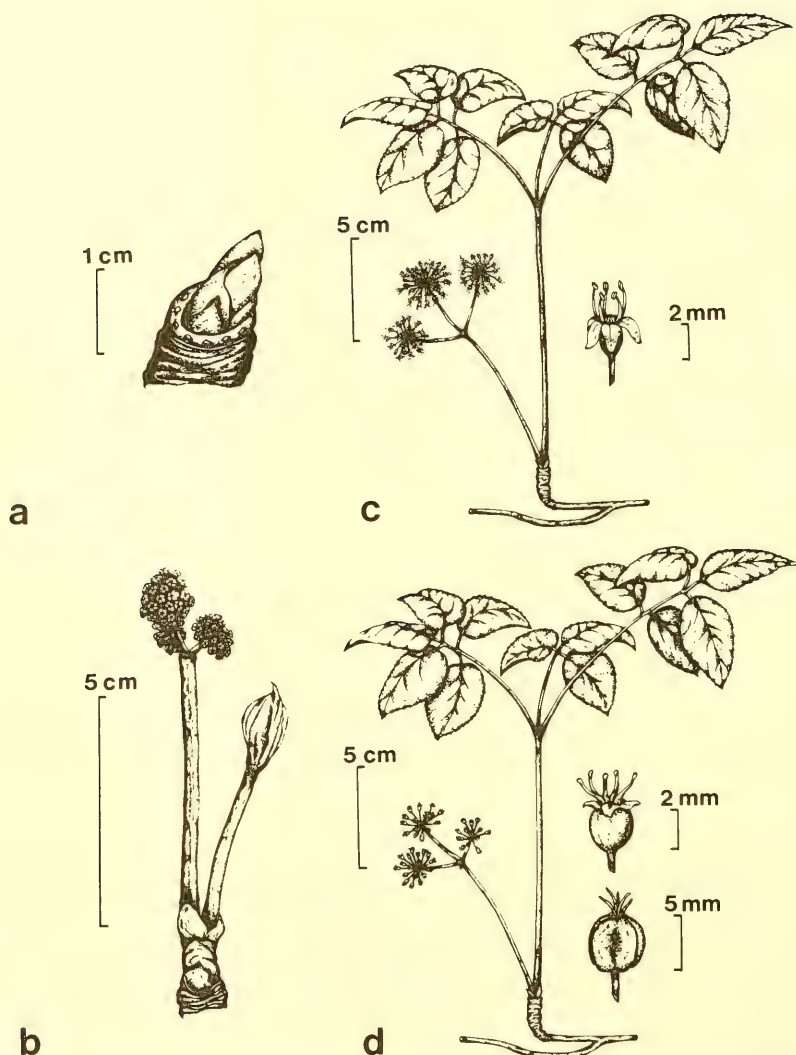


FIGURE 1. Developmental stages of *Aralia nudicaulis*: (a) the overwintering leaf bud at the top of the caudex; (b) developing leaf and inflorescence; (c) mature male reproductive ramet; inset - enlarged male flower; (d) mature female reproductive ramet (note smaller number of flowers compared to male); inset - enlarged female flower and fruit.

(e) *Subspecies*: None.

(f) *Varieties and Forms*: Two varieties, var. *prolifera* Apgar and var. *elongata* Nash, were described by Smith (1944) as fairly distinct and very local in distribution. Neither one is recognized in any regional flora consulted (e.g. Fernald 1950; Gleason and Cronquist 1963; Porsild and Cody 1980; Moss 1983; Scoggan 1979). Our examination of herbarium specimens did not reveal clear evidence of varietal or ecotypic differentiation.

(g) *Ecotypes*: None has been described.

(h) *Chromosome numbers*:

n	2n	Locality	Reference
24	(48)	Kelowna, British Columbia	Taylor and Taylor (1977)
	24	Delta, Manitoba	Love and Love (1982)
	24	North Carolina:	Blair (1975)
		Ashe Co.;	
		Durham Co.;	
		Jackson Co.;	
		Mitchell Co.;	
		Watuaga Co.;	
		Virginia:	
		Giles Co.	
	24	New Hampshire:	Bowden (1945)
		Williams Co.	

Chromosome counts to date suggest that the species is diploid throughout most of its range. The single report of tetraploidy is interesting and further studies should be undertaken to ascertain whether geographically distinct chromosome races exist. Reports of other *Aralia* species suggest that they too are diploid, although a similar polyploid series has also been reported for *A. pseudoginseng* Benth. (Sharma 1970).

3. *Distribution and Abundance*

Aralia nudicaulis is native to North America. It is a common to locally dominant understory plant in forest regions from Newfoundland to British Columbia, north to Yukon (Scoggan and Cody 1979) and the Northwest Territories (Figure 2), south to Georgia in the east and in the west to Colorado, where it is found only at higher elevations (2000-2500 m above sea level).

4. *Physical Habitat*

(a) *Climatic relations*: The distribution of *A. nudicaulis* in North America extends from latitudes higher than 60° N to latitudes lower than 40° N. This broad geographic area includes a variety of climatic regions. However, *A. nudicaulis* is confined to rich, moist woodlands and, thus, is absent from dry and open areas within its total range. In boreal mixed-wood forests in northern Alberta where *A. nudicaulis* is abundant, mean annual precipitation is 440 mm (Strong and Leggett 1981). Most of the precipitation (300 mm) comes during the summer months, May to September. The mean summer temperature is 12° C with a range from 10.5 to 14.0° C (Strong and Leggett 1981). The mean number of growing degree-days above 5° C is 1190 with a mean frost-free period of 85 days. The influence of different precipitation (moisture), temperature and photoperiod regimes on the performance of *A. nudicaulis* has yet to be investigated.

(b) *Physiographic relations*: *Aralia nudicaulis* occurs in the understory of forests on sites that range from level to very steep (40°) river bank slopes. The plant may also be found in open, regenerating clear-cut forests (Corns and La Roi 1976) and roadsides adjacent to forests (Barrett and Helenurm 1981).

The parent material of most forest soils where *A. nudicaulis* is common consists of glaciolacustrine tills. In some areas the parent material may consist of sand which originated as deltaic deposits in glacial meltwater lakes and has subsequently been modified by aeolian processes (St. Onge 1972).

The soil types in forests where *A. nudicaulis* occurs are commonly well-drained Luvisols, Brunisols, and Podzols (Canadian Soil Survey Committee 1978).

(c) *Nutrient and water relations*: Several authors have considered *A. nudicaulis* to be an indicator of moist, rich, upland sites (Dix and Swan 1971; Moss 1983). Rowe (1956) has classified the plant as ubiquitous with respect to site moisture characteristics in the Canadian prairie provinces. However, La Roi (1967) has shown that *A. nudicaulis* is rarely found in muskegs or bogs where *Picea mariana*, Black Spruce, is the dominant tree species; this indicates that the plant does not grow well in wet organic soils.

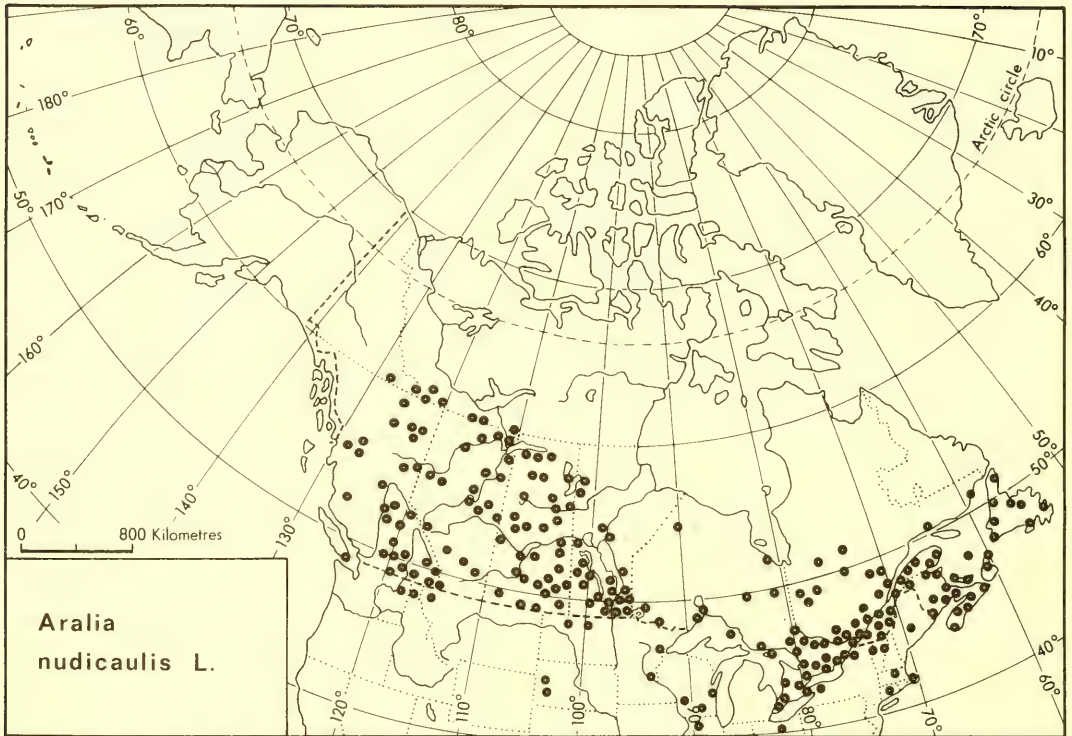


FIGURE 2. Distribution of *Aralia nudicaulis* L. in Canada. Based on specimens in the herbaria at Agriculture Canada, Ottawa, Ontario (DAO), National Herbarium, National Museums of Canada, Ottawa, Ontario (CAN), University of Alberta, Edmonton, Alberta (ALTA), University of Montreal, Montreal, Quebec (MT), McGill University, Montreal, Quebec (MTMG).

5. Plant Communities

Aralia nudicaulis L. is an important member of forest understory vegetation in the Acadian, Great Lakes-St. Lawrence and Boreal forest regions (*sensu* Rowe 1972) of Canada. Although it has been collected as far north as the Yukon and northern British Columbia (Figure 2), it generally is not a significant component of northern boreal plant communities. In more central regions it usually forms large clones in undisturbed communities.

Table 1 presents comparative data from forest stands representative of different regions across the country, seven from the Boreal forest region (1-5, 7, 8), one from the Great Lakes-St. Lawrence forest region (6) and one from the Acadian forest region (9). The data are taken from La Roi (1967) and Strong and La Roi (1983).

The stand descriptions in Table 1 were chosen not only to represent a wide geographical range but also to represent communities dominated by different overstory species. *Aralia nudicaulis* is present in Jack Pine (*Pinus banksiana*) (stand 1), Trembling Aspen (*Populus tremuloides*) (stands 2 and 3), White Spruce (*Picea glauca*)-Fir (*Abies balsamea*) and Black Spruce dominated stands. Other studies have described *A. nudicaulis* as common in birch (*Betula* sp.)-maple (*Acer* sp.), Red Oak (*Quercus borealis*), Balsam Poplar (*Populus balsamifera*), Largetooth Aspen (*P. grandidentata*) and Sugar Maple (*A. saccharum*) communities (Amiro and Courtin 1981) as well as Beech (*Fagus grandifolia*)-maple forests (Maycock 1961).

Thus, *A. nudicaulis* does not show any clear association with overstory species across its range, nor does it appear to be affected by canopy composition changes during succession. Based on studies of a successional sequence from birch to fir in the forests south of James Bay, Carleton and Maycock (1980)

TABLE 1. *Aralia nudicaulis* and associated species in forest stands^a from west to east across Canada^b.

Species	#1	#2	#3	#4	#5	#6	#7	#8	#9
<i>Pinus banksiana</i>	5	—	—	—	—	—	—	—	—
<i>Abies lasiocarpa</i>	—	—	4	2	—	—	—	—	—
<i>Pinus contorta</i>	—	—	—	3	—	—	—	—	—
<i>Populus balsamifera</i>	—	—	—	1	—	1	—	—	—
<i>Populus tremuloides</i>	—	6	—	3	1	1	1	—	—
<i>Picea glauca</i>	—	—	4	6	2	2	—	4	1
<i>Picea mariana</i>	—	—	—	1	—	1	6	1	—
<i>Betula papyrifera</i>	—	—	—	1	2	2	1	2	1
<i>Abies balsamea</i>	—	—	—	—	6	5	1	5	2
<i>Pinus strobus</i>	—	—	—	—	—	1	—	—	—
<i>Acer rubrum</i>	—	—	—	—	—	1	—	—	2
<i>Betula lutea</i>	—	—	—	—	—	—	—	—	1
<i>Alnus crispa</i>	5	4	—	1	2	—	2	—	—
<i>Corylus cornuta</i>	—	—	—	—	5	2	—	—	1
<i>Prunus</i> spp.	—	—	—	—	—	—	—	—	2
<i>Sambucus pubens</i>	—	—	—	1	1	—	—	—	1
<i>Acer spicatum</i>	—	—	—	—	6	1	—	4	2
<i>Pyrus decora</i>	—	—	—	—	3	1	2	2	—
<i>Pyrus americana</i>	—	—	—	—	—	1	—	—	2
<i>Rosa acicularis</i>	2	2	—	4	—	—	2	—	—
<i>Ribes triste</i>	—	—	—	2	2	—	1	1	—
<i>Amelanchier alnifolia</i>	—	1	—	1	—	—	—	—	—
<i>Lonicera dioica</i>	—	—	—	—	—	1	1	—	—
<i>Cornus stolonifera</i>	—	—	—	—	—	—	1	1	—
<i>Ribes lacustre</i>	—	—	—	2	—	1	—	1	—
<i>Viburnum edule</i>	—	2	1	6	1	—	1	1	—
<i>Ledum groenlandicum</i>	—	—	—	—	—	—	1	—	—
<i>Ribes glandulosum</i>	—	—	—	—	1	—	1	—	1
<i>Diervilla lonicera</i>	—	—	—	—	1	—	1	—	—
<i>Rubus ideaus</i>	—	—	—	3	3	—	—	1	1
<i>Rubus pubescens</i>	—	3	—	—	—	—	—	—	—
<i>Rubus strigosus</i>	1	2	—	—	—	—	—	—	—
<i>Amelanchier</i> spp.	—	—	—	—	2	—	1	—	—
<i>Lonicera canadensis</i>	—	—	—	—	2	1	—	—	1
<i>Amelanchier bartramiana</i>	—	—	—	—	—	—	—	1	—
<i>Corallorhiza trifida</i>	—	—	—	1	—	—	—	—	—
<i>Pyrola asarifolia</i>	—	—	—	5	—	—	—	—	—
<i>Equisetum scirpioides</i>	—	—	—	—	1	1	—	—	—
<i>Mertensia paniculata</i>	—	—	—	6	2	—	—	—	—
<i>Equisetum arvense</i>	—	—	—	1	1	—	1	—	—
<i>Fragaria virginiana</i>	—	—	—	1	1	—	—	—	—
<i>Lathyrus ochroleucus</i>	—	—	—	1	—	—	—	—	—
<i>Fragaria vesca</i>	—	—	—	3	—	—	—	—	—
<i>Pyrola virens</i>	—	—	—	1	—	—	—	—	—
<i>Habenaria obtusata</i>	—	—	—	—	—	—	—	1	—
<i>Equisetum sylvaticum</i>	—	—	—	1	1	1	1	—	—
<i>Pyrola secunda</i>	—	—	—	1	—	1	1	1	1
<i>Viola renifolia</i>	—	—	—	2	1	—	1	—	—
<i>Petasites palmatus</i>	—	—	—	1	2	1	1	—	—
<i>Moneses uniflora</i>	—	—	—	1	—	1	—	1	1
<i>Linnaea borealis</i>	2	1	r	5	—	2	5	2	2
<i>Mitella nuda</i>	—	—	—	6	5	3	2	1	1
<i>Apocynum androsaemifolium</i>	—	—	—	—	1	—	—	—	—
<i>Cornus canadensis</i>	—	2	r	6	1	3	5	3	4
<i>Goodyera repens</i>	—	—	—	1	1	1	1	1	—
<i>Lycopodium annotinum</i>	—	—	—	1	1	2	—	—	—

(Continued)

TABLE 1. (Continued)

Species	#1	#2	#3	#4	#5	#6	#7	#8	#9
<i>Circaea alpina</i>	—	—	—	1	1	—	—	—	—
<i>Anemone quinquefolia</i>	—	—	—	—	1	1	1	—	—
<i>Actaea rubra</i>	—	—	—	1	1	1	—	1	—
<i>Galium boreale</i>	—	—	r	—	—	—	—	—	—
<i>Galium triflorum</i>	—	—	—	2	2	1	—	—	—
<i>Aralia nudicaulis</i>	2	4	r	6	6	2	4	4	1
<i>Rubus pubescens</i>	—	—	—	6	1	1	2	2	1
<i>Aster macrophyllus</i>	—	—	—	—	5	1	1	—	1
<i>Habenaria orbiculata</i>	—	—	—	—	—	—	—	1	—
<i>Gymnocarpium dryopteris</i>	—	—	—	6	1	2	4	1	—
<i>Vaccinium myrtilloides</i>	1	1	—	—	—	1	2	—	1
<i>Arctostaphylos uva-ursi</i>	1	—	—	—	—	—	—	—	—
<i>Schizachne purpurascens</i>	—	—	—	—	1	—	1	—	1
<i>Athyrium filix-femina</i>	—	—	—	1	3	—	—	—	—
<i>Cinna latifolia</i>	—	—	—	2	1	1	1	—	1
<i>Vaccinium vitis-idaea</i>	1	1	—	—	—	—	—	—	—
<i>Vaccinium angustifolium</i>	—	—	—	—	—	1	1	—	—
<i>Maianthemum canadense</i>	1	1	—	2	4	2	6	5	2
<i>Calamagrostis canadensis</i>	—	1	—	—	—	—	—	—	—
<i>Elymus innovatus</i>	—	1	r	—	—	—	1	—	—
<i>Epilobium angustifolium</i>	—	1	—	—	—	—	—	—	—
<i>Pteridium aquilinum</i>	—	—	—	—	—	1	—	—	3
<i>Trientalis borealis</i>	—	—	—	—	2	1	1	2	1
<i>Streptopus roseus</i>	—	—	—	—	1	1	—	2	1
<i>Streptopus amplexifolius</i>	—	—	—	1	—	—	2	1	—
<i>Smilacina trifolia</i>	—	—	—	—	—	—	1	—	—
<i>Osmunda claytoniana</i>	—	—	—	—	1	—	—	1	3
<i>Lycopodium obscurum</i>	—	—	—	—	2	1	—	1	1
<i>Clintonia borealis</i>	—	—	—	—	5	1	3	4	2
<i>Oxalis montana</i>	—	—	—	—	—	3	—	6	5
<i>Coptis groenlandica</i>	—	—	—	—	1	1	3	3	2
<i>Dryopteris austriaca</i>	—	—	—	—	1	2	1	3	2
<i>Viola incognita</i>	—	—	—	—	—	2	—	1	1
<i>Gaultheria hispida</i>	—	—	—	—	—	1	5	—	1
<i>Solidago macrophylla</i>	—	—	—	—	—	—	—	1	1
<i>Thelypteris phegopteris</i>	—	—	—	—	2	—	—	2	1
<i>Monotropa uniflora</i>	—	—	—	—	—	1	—	—	1
<i>Lycopodium lucidulum</i>	—	—	—	—	—	1	—	—	1

^aStands 1 to 3 taken from Strong and La Roi (1983) (1 = stand #3; 2 = stand #10; 3 = stand #4). Cover classes r = 1%; 1 = 1-5%; 2 = 6-15%; 3 = 16-25%; 4 = 26-50%; 5 = 51-75%; 6 = 76-95%.

Stands 4 to 9 taken from La Roi (1967). All are White Spruce stands (4 = stand #12; 5 = stand #19; 6 = stand #21; 8 = stand #28; 9 = stand #30) except #7, which is Black Spruce (7 = Black Spruce Stand #17). Abundance notation differs for trees, shrubs and herbs. Consult La Roi (1967) for details.

^bStands 1 to 3 Alberta (55° 15' N, 114° 0' W; 4 Alberta (54° 21' N, 116° 35' W); 5 Western Ontario (48° 54' N, 90° 25' W); 6 Northern Michigan (46° 15' N, 87° 25' W); 7 Northeastern Ontario (49° 14' N, 80° 39' W); 8 Québec (49° 45' N, 68° 41' W); 9 New Brunswick (46° 47' N, 66° 31' W).

concluded that *A. nudicaulis* was a member of a species group including *Cornus canadensis*, *Maianthemum canadense*, and *Clintonia borealis*, which seemed indifferent to canopy change.

Aralia nudicaulis also appears to be relatively insensitive to soil moisture changes. Maycock (1961) described *A. nudicaulis* on Mt. St. Hilaire (Quebec) as very ubiquitous and present in stands in all segments of the moisture gradient (but see section 4c).

Although apparently common and shade tolerant as a boreal and cool-temperate forest understory species, *A. nudicaulis* is not common in open canopy communities such as either the open 'barren community' or the relatively open 'birch transition' community analyzed by Amiro and Courtney (1981).

6. Growth and Development

(a) *Morphology*: The mature plant overwinters in a leafless state. The overwintering bud, which is located at the top of the caudex (Figure 1a), occurs in the leaf litter or upper horizon of the mineral soil. In the spring after air and soil temperatures have increased, the bud swells and leaf growth and development are initiated. If a shoot is reproductive, inflorescence development is concomitant with leaf development. The petiole and scape elongate before the leaflets unroll and the flowers open (Figure 1b). The leaflets are brown initially and do not mature until approximately one week after unrolling. Flower opening occurs centripetally within an umbel. In male flowers petals and stamens remain attached until after the pollen is shed (Figure 1c). After pollination the ovary of the female flower swells but then does not ripen for approximately one month. We have been unable to germinate seeds and know of no published accounts of seedling growth and development (see section 7c).

Barrett and Helenurm (1981) studied the relative growth rates of male and female shoots in the field. Growth rates were calculated for vegetative parts in both sexes based on three weekly harvests during leaf development. The relative growth rate for females was $.310 \pm .098 \text{ g.g}^{-1}.\text{wk}^{-1}$, which was significantly higher than the $.154 \pm .066 \text{ g.g}^{-1}.\text{wk}^{-1}$ recorded for male shoots. Differences in relative growth rate between the sexes were evident in the month of June. For the remainder of the season little shoot growth occurs and senescence rates are similar in male and female ramets (Barrett and Helenurm 1981).

The reproductive effort (expressed as a percentage of total shoot weight) and the absolute biomass of reproductive structures of male shoots are significantly higher than females in early June due to the larger number of flowers on male inflorescences. At peak flowering, the reproductive effort of male shoots is $17.1 \pm 4.4\%$ compared to $10.1 \pm 2.5\%$ in females (Barrett and Helenurm 1981). However, the relationship is reversed within a two-week period as a result of the termination of female flowering and the initiation of fruit development. Reproductive expenditure in females increases during June and reaches a maximum of $23.3 \pm 8.9\%$ in early July (Barrett and Helenurm 1981). For a six-week period, during which the fruit develops and matures, the female shoots incur a reproductive cost not experienced by male shoots.

The pattern of biomass allocation for vegetative ramets is listed in Table 2.

(b) *Physiology*: Almost nothing is known about the physiology of *A. nudicaulis*. The pattern of ^{14}C assimilate distribution in *A. nudicaulis* was studied by Flanagan and Moser (1985a) to determine the extent of physiological integration among individual shoots in a clone. Most of the labelled carbohydrate exported from a shoot was translocated basipetally into the rhizome from which the shoot emerged. While the rhizome basipetal to a shoot accumulated the highest amount of labelled carbon because of its role as a major storage organ, the roots and new developing rhizomes adjacent to a shoot had the highest specific activity, indicating that they were strong sinks during growth and development. Changes in the normal translocation pattern were observed when one shoot was shaded before an adjacent shoot was labelled. There was an increased amount of carbohydrate translocated from an unshaded shoot to the root and rhizome components adjacent to a shaded shoot. The changed pattern of translocation after disturbance indicated the potential for physiological integration among shoots within a clone (Flanagan and Moser 1985a).

TABLE 2. Mean dry weight (mg) of vegetative components of *Aralia nudicaulis* L. grown in the greenhouse (n = 10).

Component	Mean	Standard Deviation	Maximum	Minimum
Leaflets	1319.0	840.0	2726.8	166.7
Petiole	166.7	96.5	318.5	61.8
Caudex	1439.3	827.1	2743.4	201.1
Rhizome*	5585.1	1489.5	8431.9	3967.9
Root**	1085.1	709.4	2626.2	78.1

*Weight of total length of rhizome connecting two shoots.

**Weight of all roots produced along a rhizome connecting two shoots.

(c) *Phenology*: In central Alberta, bud break occurs during May and early June. Some preliminary data suggest that bud break is initiated after daily minimum temperatures rise above 0° C. Rapid elongation and development of the leaf results in the plant reaching maximum height within two weeks of growth initiation. The next season's bud is formed by the middle of July. The leaf remains fully expanded and mature for approximately 115 days (until mid-September) before leaf senescence occurs.

Floral development is concomitant with leaf development. Flowers may be open and functional before the leaf has completed development. Flowering normally occurs during late May and early June, with female flowers opening before male flowers (Moss 1960; Barrett and Helenurm 1981; Barrett 1984; Flanagan and Moser 1985b). After pollination, fruit, which ripens in late July or early August, is produced. Virtually all the fruit are dispersed by the end of August.

7. *Reproduction*

(a) *Floral biology*: *Aralia nudicaulis* is primarily dioecious with some rare inflorescences containing perfect flowers or both male and female flowers (Barrett and Helenurm 1981; Bawa et al. 1982). The female flowers have five long styles and five short stamens with non-functional anthers. After a flower opens the styles lengthen and diverge while the stamens and green petals fall off. Stigmas are receptive for six days after the styles diverge (Barrett and Helenurm 1981). The ovary of the female flower begins to swell after pollination and reaches full size in less than one week. The berry-like drupe remains green for approximately one month, ripening and turning black in late July or August.

The male flowers have five long stamens with bright white anthers and five short styles in a non-functional pistil. The stamens fall off after the pollen is shed. In most cases the male inflorescence withers and dies after the flowers have shed their pollen. In some male flowers the styles lengthen and diverge after the stamens have fallen off. In these cases, the ovary may swell and produce a fruit, but the fruit contains no seed, so that the flowers remain functionally male.

Male inflorescences have, on average, twice as many flowers as female inflorescences (99.6 vs. 49.8, $t = 25.2$, $p = .001$; Flanagan and Moser 1985b). The difference in flower number between the sexes results from females having fewer flowers per umbel than males, since the majority of inflorescences in both sexes have three umbels. Females, however, have a significantly higher frequency of two-umbel inflorescences while males have a higher frequency of four-umbel inflorescences (Flanagan and Moser 1985b). Flower number is correlated with flowering time within a season. Individual female ramets which flower early in the season have fewer flowers than later flowering ramets (Flanagan and Moser 1985b).

The sexes also differ in aspects of their flowering phenology. Female inflorescences begin flowering earlier and reach peak flowering before males (Barrett and Helenurm 1981; Flanagan and Moser 1985b). The peak flowering time of females is from 2 to 4 days earlier than males.

Aralia nudicaulis is insect-pollinated. Pollination is required for seed set because there is no apomictic seed production (Flanagan and Moser 1985b).

(b) *Seed production and dispersal*: Fruit production is generally high (90-100% fruit set) but seed production is lower than potential. On average, only two of the five seeds per fruit ripen. In Alberta, individual ramets produced an average of 100 seeds per year in 1983-84 (Flanagan and Moser 1985b). Lack of pollination is not the cause of low seed production. Addition of pollen in excess of natural pollination only slightly increased seed set per flower in one of two study seasons. Seed set was never higher than an average of 2.9 seeds per flower; this suggested that resource limitation reduces seed production (Flanagan and Moser 1985b). Individual ramets exhibit a differential seed set as a function of their flowering time within a season. Seed production was highest in ramets that flowered during the peak flowering period in one season and was highest in ramets that flowered during the later stages of flowering in another season. There was a weak negative correlation between ramet size and seed production (Flanagan and Moser 1985b).

Fruit of *A. nudicaulis* matures in late July and early August in natural populations of the plant. The fruit is eaten and the seeds are dispersed in the scats of several mammals (Edwards 1984) and forest bird species (Beal 1915).

(c) *Seed viability and germination*: There are few published reports of seed germination in *A. nudicaulis*. Nichols (1934) and Krefting and Roe (1949) both reported that seed germination is very low. Cold treatment has been shown to be a requirement for seed germination (Nichols 1934). Several attempts to break the dormancy of *A. nudicaulis* seeds using various treatments (gibberellic acid, scarification, cold

treatment) have not been successful (Flanagan *unpublished*). The establishment of new genets by seed germination probably occurs only rarely. We have never observed seedlings in the field.

(d) *Vegetative reproduction*: The principal mode of reproduction in *A. nudicaulis* is by growth of the rhizome. Clonal growth can result in extensive areas being occupied by ramets of a single genet. The largest clone excavated by Edwards (1984) had a diameter of 7 m, which was considered to be a very conservative estimate of clone size because rhizomes enmeshed in the root systems of trees could not be followed. The clone excavated consisted of 27 ramets, only three of which were flowering. The distance between two ramets on a linear sequence of rhizome was rarely < 1 m and in some cases was > 3 m. The rhizome does not readily fragment, so that the connections between distant ramets may persist for several years. The 27 excavated ramets ranged in age from 1 to 26 years (Edwards 1984). Shoots are not always produced sequentially as the rhizome grows, since the ages of shoot caudices do not necessarily increase with increasing distance from the growing rhizome tip. This pattern suggests that new young shoots can differentiate from buds along the rhizome at various times during the development of a clone.

8. Population Structure and Dynamics

(a) *Dispersion patterns*: Ramets of *A. nudicaulis* have a clumped spatial pattern. Morisita's index of dispersion for a wide range of quadrat sizes indicates that significant clumping occurs at a scale of 0.25 m both for total shoots and for flowering shoots alone (Edwards 1984). Flowering shoots show more clumping than all shoots taken together.

A group of nearest-neighbour shoots which form a local patch are unlikely to be from the same rhizome system. Excavation of clones indicates that ramets connected to the same rhizome system are widely separated (0.9 m to greater than 3 m, Edwards 1984) and occupy many different patches. The above-ground patches are a result of different rhizome systems producing shoots in the same area.

On a larger spatial scale (90 m²), male and female flowering ramets often occur in patches which are sexually segregated (Barrett and Thomson 1982). Male flowering ramets occur in patches with greater densities than females (Barrett and Thomson 1982; Bawa et al. 1982). The sexual segregation of flowering ramets is probably primarily related to the clonal nature of the plant (Barrett and Thomson 1982). Clones of a different sex may have initially been established in different areas of the forest. However, the negative association of ramets may also result from differences between the flowering behaviour of the males and females. Female flowering ramets are less likely to be found in shaded areas of a forest than are males (Barrett and Thomson 1982). This may indicate sexual differences in the light requirements necessary for flower initiation. The observed spatial segregation may also be related to differences in the frequency of flowering in the two sexes (see below).

The higher degree of clumping among reproductive shoots may in part be a result of moose herbivory patterns (Edwards 1984). The pattern of moose herbivory is patchy, and moose prefer flowering shoots to vegetative shoots (Edwards 1985). Herbivory reduces the capacity for flowering in the subsequent season; this would decrease the number of patches of flowering shoots and would result in a higher Morisita index value (Edwards 1984, 1985).

(b) *Age distribution*: Individual ramets of *A. nudicaulis* are very long lived. Age distributions from three boreal forest habitats in northern Alberta indicate that the mean age of a ramet is 19.5 years (Figure 3). Ramets ranged in age from 5 to > 40 years. This suggests that individual genets must be extremely old. Edwards (1985) has shown that reproductive shoots are significantly older (mean 12.5 years) than vegetative shoots (6.9 years). All but one of the flowering shoots in Edwards' (1985) study was at least 5 years old.

(c) *Size distribution*: Female ramets exceed males in both total and vegetative biomass (Barrett and Helenurm 1981). However, in terms of petiole length, leaflet number and leaflet size, no differences between male and female ramets are apparent (Table 3).

Female flowering shoots are significantly larger than non-flowering shoots (Table 3). Male flowering shoots have longer petioles than non-flowering shoots, but the two are not significantly different with respect to leaflet number and performance index (PI; Table 3).

Non-flowering shoots have a very broad size distribution relative to females and males (Figure 4). The shoot with the largest PI measured in this sample was a non-flowering shoot. Therefore, the change from a flowering to non-flowering shoot is not directly controlled by reaching a size threshold.

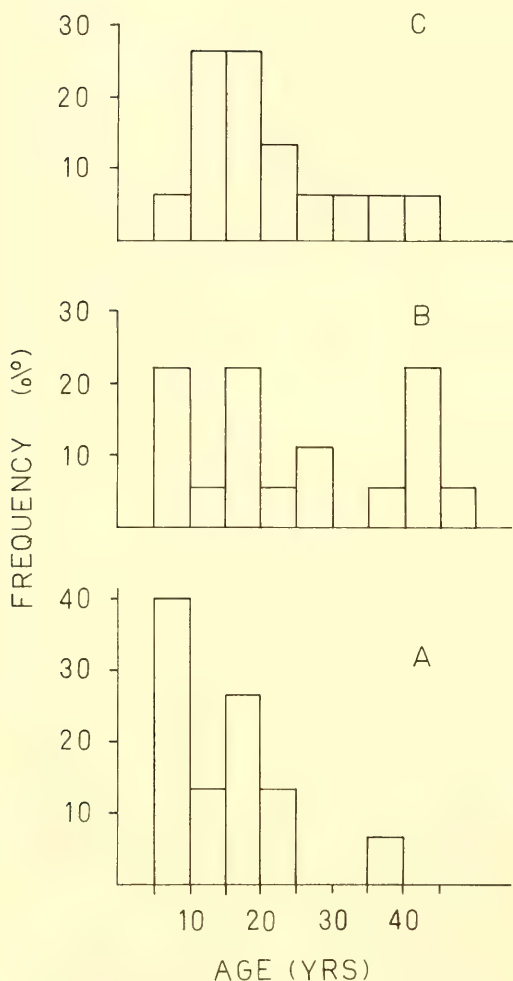


FIGURE 3. Population age structure for *Aralia nudicaulis* in three successional plant communities: A) Stand 2; B) Stand 3; C) Stand 4 of Strong and La Roi (1983). N = 20 for each stand.

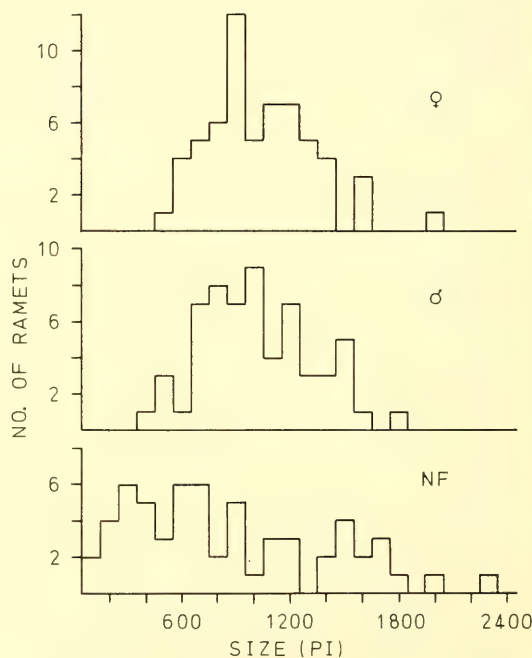


FIGURE 4. Frequency distribution of Performance Index in female, male and non-flowering shoots of *Aralia nudicaulis* in 1983. Measurements were made on plants in reference stand #3 of Strong and La Roi (1983). Performance Index is defined in Table 3.

In shaded habitats *A. nudicaulis* produces smaller leaflets than in open areas. In extremely shaded habitats not only is leaflet size reduced but leaflet number is also reduced (Table 4).

(d) *Growth and turnover rates*: Male-biased floral sex ratios have been reported for several natural populations of *A. nudicaulis* in New Brunswick and Massachusetts (Barrett and Helenurm 1981; Bawa et al. 1982). The male-biased floral sex ratio results from differences in the frequency of flowering between the two sexes (Table 5). Of the Alberta ramets marked in 1983, only 4.8% of the females flowered again in 1984, while 39.1% of the males flowered again in 1984. Similar differences between the sexes in consecutive flowering pattern were observed in 1984-85, but higher percentages of both male and female ramets flowered in 1985. Approximately 10% of the flowering ramets marked in one season produced no leaf the following season.

TABLE 3. Mean values for the leaf characteristics of flowering and non-flowering *Aralia nudicaulis* L. ramets during 1983*. Differences among ramet types were determined by nonparametric multiple comparison tests after Kruskal-Wallis analysis of variance. Within each row, values followed by the same letter are not significantly different ($P > 0.05$).

Characteristic	Ramet Type		
	Female	Male	Non-flowering
Petiole Length (cm)	24.25 ^a	26.89 ^a	21.87 ^b
Leaflet Number	14.28 ^a	13.07 ^{ab}	12.53 ^b
Performance Index**	1040.8 ^a	1012.4 ^{ab}	852.7 ^b
n	60	60	60

*Measurements made on plants in reference stand #3 described in Strong and La Roi (1983) (Stand #1, Table 1).

**Performance Index = $n (L_1 W_1 + L_2 W_2) / 2$ where n = the number of leaflets per shoot, and L, W = the length and width (cm) of the two largest leaflets per shoot. PI is linearly related to leaf area (LA) and is approximately twice as large ($PI = 1.8 LA + 13.05$, $r = 0.99$, $P < 0.001$).

(e) *Successional role*: *Aralia nudicaulis* is an abundant understory herb in the boreal forest where extensive wildfires are frequent (Rowe and Scotter 1973). *Aralia nudicaulis* is present in a wide variety of plant communities ranging from young, post-fire, seral communities to old White Spruce-Fir communities. This may be attributed to the ability of the rhizome to survive many fires while protected in the mineral soil (Flinn and Wein 1977). Regeneration of shoots from buds on rhizome fragments may allow quick recolonization after fire. Fire may also provide suitable environmental conditions for seed germination. A common characteristic of many boreal forest understory species, including *A. nudicaulis*, is the lack of response to qualitative changes in, or affinity for, any forest canopy type (Carleton and Maycock 1980, 1981). However, in extremely low light regimes under mature White Spruce-Fir forests, reproductive performance (Barrett and Thomson 1982) and vegetative vigor are reduced (Table 4).

Aralia nudicaulis is also able to survive disturbances like forest clear-cutting. Corns and La Roi (1976) have noted the presence of *A. nudicaulis* in Lodgepole Pine, *Pinus contorta*, sites which had been clear-cut and scarified seven years before sampling.

9. Interaction with Other Species

(a) *Competition*: *Aralia nudicaulis* may be affected by reduced light intensity when associated with the shrubs *Alnus crispa*, *Rosa acicularis*, *Shepherdia canadensis*, *Viburnum edule*, or the fern, *Pteridium aquilinum*, which overtop it.

Competition for water and nutrients may occur with any of the many understory herbaceous plants which have shallow roots in the organic layer and upper levels of the mineral soil. Some of these species which are commonly associated with *A. nudicaulis* are *Clintonia borealis*, *Cornus canadensis*, *Epilobium angustifolium*, *Lycopodium annotinum*, *Maianthemum canadense*, *Mertensia paniculata*, and *Trientalis borealis*. The feather moss species *Pleurozium schreberi*, *Hylacomium splendens* and *Ptilium crista-castrensis* may also compete with *A. nudicaulis* for water and nutrients.

Understory species that bloom synchronously with *A. nudicaulis* and are bee-pollinated may compete for pollinator service. Any of the herbaceous angiosperms listed above could potentially compete for pollinators.

(b) *Symbiosis*: The major pollinators of *A. nudicaulis* are the bumble bees, *Bombus vagans* F. Smith and *B. ternarius* Say. Other flower visitors include andrenids, halictids, syrphids, small flies and thrips (Barrett and Thomson 1982; Bawa et al. 1982).

Malloch and Malloch (1981) have shown that endomycorrhizae are commonly associated with the roots of *A. nudicaulis* but the fungi involved were not identified.

(c) *Predation and parasitism*: Grazing by Moose (*Alces alces*) on *A. nudicaulis* may be intense in some areas. On Isle Royale, Michigan, Edwards (1985) has shown that the proportion of *A. nudicaulis* shoots

TABLE 4. Mean values for the leaf characteristics of 30 *Aralia nudicaulis* ramets in three successional related plant communities in the boreal forest near Hondo, Alberta. Differences between stands were determined by Kruskal-Wallis and nonparametric multiple comparison tests.

	Reference Stand*		
	2	3	4
Leaflet size (L x W = cm ²)	79.2 a***	53.8 b	24.2 c
No. of leaflets	12.6 a	13.2 a	6.9 b
PI**	1052.6 a	746.4 b	195.1 c

*Reference Stand # from Strong and La Roi (1983).

Stands 2 to 4 are progressively more shaded (see Ross et al. (1986)).

**Performance Index is defined in Table 3.

***Within each row, values followed by the same letter are not significantly different, $P > 0.05$.

eaten increased with shoot density from 11% in quadrats with less than nine shoots m⁻² to 77% in quadrats with over 20 shoots m⁻². Reproductive shoots were grazed more often (63% affected) than vegetative shoots (33% affected). Other grazers included Snowshoe Hares (*Lepus americanus*), and meloid beetles (*Epicauta murina*; Edwards 1985).

The fruit of *A. nudicaulis* is eaten by Black Bears (*Ursus americanus* Pallas), Red Foxes (*Vulpes vulpes* L.), Wolves (*Canis lupus* L.; Edwards 1985) and several forest bird species including the thrushes *Catharus ustubatus* and *C. guttatus* (Beal 1915).

A rust, *Myrsinepsora clavellata* (Berk.) Arth. attacks *A. nudicaulis* throughout most of its Canadian range (Savile 1975). A fruticolous smut, *Mundkurella mossii*, of *A. nudicaulis* is known mainly from Alberta and Saskatchewan. It is not clear whether the smut is perennially systemic in the rhizome or only annually systemic in individual flowering shoots (Savile 1975).

10. Evolution and Migration

Species of the genus *Aralia* are found in Asia and Malaysia as well as North America. Numerous *Aralia* fossils have been described (Berry 1903), including some of Tertiary age from regions of Alaska where *Aralia* is no longer present. The evidence suggests, therefore, that ancestral *Aralia* species existed in the Tertiary mesophytic forest which was circumpolar at that time.

Aralia nudicaulis is not closely related to other North American species (Harms 1898). No evidence of hybridization has been discovered. Aside from the recent report of tetraploidy (Taylor and Taylor 1977), all information suggests that the species is a very homogeneous, well-defined assemblage.

11. Response Behaviour

(a) *Fire*: *Aralia nudicaulis* may survive the effects of many forest fires because its rhizome occurs at a mean depth of 6 cm in the mineral soil (Flinn and Wein 1977). Species with regenerative organs located primarily in the mineral soil will have the greatest survival rate during fire. New leaves of *A. nudicaulis* produced from buds on rhizomes have been observed in the field the season after a forest fire occurred.

(b) *Grazing*: Those shoots of *A. nudicaulis* whose leaves had been experimentally clipped produced significantly fewer fruits than intact shoots during the experimental season (Edwards 1985). Five of 42 clipped reproductive shoots and 28 of 37 clipped vegetative shoots produced a new leaf during the season clipping was performed. However, in all but one case the newly produced leaf was smaller than its intact matched shoot. In the following year, none of the clipped shoots flowered. A relatively high percentage of previously marked, intact reproductive (29%) and vegetative shoots (11%) flowered in the following year. Clipping had no effect on survivorship of shoots (Edwards 1985).

(c) *Flooding*: High levels of soil moisture are not tolerated by *A. nudicaulis*. Maintaining *A. nudicaulis* in the greenhouse in continuously wet soil results in rotting of the rhizome and subsequent death of the plant.

TABLE 5. Demographic behavior of *Aralia nudicaulis* flowering ramets*. Flowering ramets were marked in 1983 and classified into the three classes shown below in 1984. A similar procedure was followed for a new group of flowering ramets marked in 1984 and followed to 1985. The response of the sexes is significantly different (chi-square = 38.3, 2df, $P < 0.001$ for 1983-84; chi-square = 17.5, 2df, $P < 0.001$ for 1984-85).

	Leaf and Inflorescence	Leaf	No Leaf	Total
1983-84				
Male	26 (35.1%)	42 (56.8%)	6 (8.1%)	74
Female	8 (4.8%)	140 (85.4%)	16 (9.8%)	164
1984-85				
Male	51 (53.1%)	34 (35.4%)	11 (11.5%)	96
Female	32 (26.7%)	75 (62.5%)	13 (10.8%)	120

*Observations made on plants in reference stand #3 described in Strong and La Roi (1982) (Stand #1, Table 1).

(d) *Insecticide*: In New Brunswick aerial insecticide spraying (fenitrothion) for spruce budworm can affect the fecundity of entomophilous plants. *Aralia nudicaulis* showed significantly lower fecundity in sprayed relative to unsprayed areas (Thaler and Plowright 1980). This difference in fecundity is thought to be related to the mortality of insect pollinators, particularly bumble bees, in the sprayed area.

12. Relationship to Man

Although *Aralia nudicaulis* is of no contemporary economic importance, it was apparently of some use (mostly medicinal) in the past. The Bella Coola made a refreshing beverage by boiling the rhizomes in tall wooden boxes until the water was reddish-brown. After the coming of Europeans this "tea" was sweetened with sugar. It was also taken as a medicine for stomach pains (Turner 1975). Boiled and powdered roots were used by some North American Indians as a cough remedy (Lewis and Elvin-Lewis 1977), while Fernald (1950) and Marie-Victorin (1964) state that the roots have been used in folk medicine as a substitute for officinal sarsaparilla (from *Smilax* sp.). The latter author also mentions that one can make from the fruits "un vin de ménage aromatique".

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Notes

Nesting of King Eiders, *Somateria spectabilis*, and Snowy Owls, *Nyctea scandiaca*, near Cape Churchill, Manitoba

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Moser, Timothy J., and Donald H. Rusch. 1988. Nesting of King Eiders, *Somateria spectabilis*, and Snowy Owls, *Nyctea scandiaca*, near Cape Churchill, Manitoba. *Canadian Field-Naturalist* 102(1): 60-61.

We report the nesting of King Eiders (*Somateria spectabilis*) (second and subsequent records for Manitoba), and Snowy Owls (*Nyctea scandiaca*) (first records for Manitoba since 1936), near Cape Churchill, Manitoba.

Key Words: Snowy Owl, *Nyctea scandiaca*, King Eider, *Somateria spectabilis*, nests, breeding range, tundra, Manitoba.

Our purpose is to report nests of King Eiders (*Somateria spectabilis*) and Snowy Owls (*Nyctea scandiaca*) near Cape Churchill, Manitoba (58°46'N, 93°16'W). Our observations were made in the "coastal tundra" zone (Wellein and Lumsden 1964) of the Hudson Bay Lowlands from April to August 1981-84 and from 12 June to 1 July 1985. The study area lies 58 km ESE of Churchill, within 5 km of Hudson Bay and more than 15 km beyond the treeline. This area was included in recent studies of avifauna by Jehl and Smith (1970) and Cooke et al. (1975).

KING EIDER. Adult drakes or pairs were observed from 7 to 29 June 1983 and from 20 May to 25 June 1984. Observations spanned only seven-day periods in June and July of 1981 and 1982. On 22 June 1983 a female, judged to be a King Eider by its color and bill morphology, flushed from a nest containing one egg. An adult drake King Eider had been circling the nest site during our approach (approximately 5 min). The egg measurements (62.9 × 44.8 mm), and down and contour feathers collected from the nest, most resembled those of King Eiders (Bent 1925; Cramp and Simmons 1977; Harrison 1978). The nest subsequently was found destroyed. On 29 June another drake King Eider behaved similarly around a hen and nest containing four eggs. This nest was also subsequently destroyed.

On 13 June 1985 a female King Eider flushed from a one-egg nest. A drake King Eider was also

present. On 19 June 1985 a King Eider female flushed from the same nest that contained six fresh eggs; no male was observed. Egg measurements ($\bar{x}$ = length = 62.5 mm, $\bar{x}$ width = 43.0 mm), down coloration, and photographs of the female indicate their identity as *S. spectabilis*. This nest was found destroyed, apparently by avian predators, on 25 June. King Eider nesting has been recorded farther north in the North-west Territories (Godfrey 1966) and there is evidence of breeding to the south in Ontario (Alison 1975). There is only one previous nesting record in Manitoba, however (Abraham and Cooke 1979). King Eiders were reported as rare migrants or visitors by Jehl and Smith (1970) and Cooke et al. (1975). Our observations suggest that King Eiders may now nest relatively frequently near Cape Churchill. Common Eiders (*Somateria mollissima*) nest annually on our study area at low densities (< 0.2 nests/km²).

SNOWY OWL. On 12 June 1984 we visited a Snowy Owl nest containing six eggs which we estimated had been incubated 17 days. Both adults were present. Eggs were still intact on 25 June and three young near fledging age were observed from a helicopter on 5 August. We frequently sighted owls 4 km to the north and P. Majewski and J. Reynolds (personal communication) saw two owls copulating in the area on 27 May, which suggested the presence of another breeding pair.

On 12 June 1985, one adult flushed from a beach ridge nest containing seven eggs, one of which was

infertile (or its embryo had died very early). On 20 June one adult flushed from the same nest that contained four owlets and three intact eggs. Prey items at the nest included three Snow Goose goslings (two blue phase and one snow phase) (*Chen caerulescens*). During a visit on 24 June one adult flushed from the nest and feigned injury approximately 100 meters from the nest. The nest contained three owlets, one pipped egg and one intact egg. A partially consumed male Willow Ptarmigan (*Lagopus lagopus*) was near the nest. On 1 July no young were found at the nest and were presumed to have been killed by predators. Another nest was found on a hummock in a sedge meadow on 24 June 1985. One adult and four owlets were observed on 24 and 27 June and 1 July 1985. A third nest found in 1985 was visited only once. The nest, on a hummock in a sedge meadow, contained two eggs and was attended by two adults on 23 June.

Snowy Owl nesting in Manitoba was last reported in 1936 (Shelford and Twomey 1941). Owls were observed during the nesting season near Cape Churchill in 1968 (Jehl and Smith 1970) and by us in 1981 but showed no evidence of breeding. One of us (D. H. R.) found no evidence of owls nesting during breeding season visits to the study area in 1971-1980. Local Collared Lemming (*Dicrostonyx groenlandicus*) populations appeared very high in 1984, and to a lesser degree in 1985, based on the frequency of sightings of Lemmings, remains of winter nests, and fecal piles. In 1984 and 1985 we also observed increases in the abundance and nesting effort of other species (Moser and Rusch 1988) that prey heavily on microtine populations. Snowy Owls and other predators may also be responding to the additional prey base provided by recent increases in the numbers of Snow Goose broods using the area south of Cape Churchill.

Snowy Owls were commonly observed by us from 9 May to 15 July in 1981 and 4 May to 8 June in 1982. Our earliest observation was 21 April 1983.

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A Replacement Clutch in Wild Gyrfalcons, *Falco rusticolus*, in the Northwest Territories

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A pair of Gyrfalcons (*Falco rusticolus*) in the Northwest Territories laid a replacement clutch after abandonment of its initial set of eggs as a result of disturbance. Renesting in wild Gyrfalcons is uncommon.

Key Words: Gyrfalcon, *Falco rusticolus*, breeding, renest, Northwest Territories.

The practice of producing a second or replacement clutch when the first is destroyed or abandoned is common among most raptors (Newton 1979). The majority of falcons, for example, will renest if the initial clutch is lost within the first 2 wk of incubation (Cade 1982). However, renesting has rarely been reported in falcons larger than the Peregrine (*Falco peregrinus*) (Newton 1979; Morrison and Walton 1980, Allen et al. 1986). Additionally, within a species the frequency of renesting tends to decrease at higher latitudes (Cade 1960; Newton 1979). This paper reports on an observation of renesting in Gyrfalcons (*F. rusticolus*) in a population in the Northwest Territories (N.W.T.) (approximately 68°N, 107°W), and reviews the available literature on renesting in this species.

A Gyrfalcon population of between 14 and 18 territorial pairs was studied in an area of 2000 km² of rugged tundra from 1982 to 1986. For details on survey techniques and methods, and description of the study area, see Poole and Bromley (1988).

The renesting incident described here resulted from nest abandonment unintentionally induced by human disturbance. On 22 May 1985, a Super-8 time-lapse movie camera unit (after Temple 1972), set to take one frame every 3 min, was placed approximately 3 m from Gyrfalcon Site 113 containing four eggs. The film recorded activity at the nest ledge for 1 wk, and showed that incubation effectively ended at camera placement. The daily minimum ambient temperature ranged from -4 to 0°C. Brief individual visits by both adults were recorded up to 5 d after camera placement, but these visits never totaled more than 3% of the frames in any day. Three periods of incubation, one by the female and two by the male, were recorded on 24 May, but only lasted for one or two frames. On 29 May the camera unit was removed

and the cold eggs collected. Both adults were present in the nest area.

In mid-July the pair was found nesting approximately 450 m southwest of the original nest in Site 1197. Although the adults were not banded, there is little doubt that the pair were the same birds. Detailed notes on and photographs of the plumage of most Gyrfalcons in the study area have been taken; in this case a white female and a grey male with a dark malar bar. Two female chicks were raised to at least banding age from a clutch of three eggs. The third egg, of unknown fertility, did not hatch. The site was last visited on 7 August when the chicks, estimated at 22 and 24 d of age, were banded and measurements taken.

The date of initiation of laying of the first clutch was likely between 8 and 13 May, the range for the other eight Gyrfalcon sites productive in 1985, as determined by direct observation of hatching or back-dating from estimated age of nestlings. A 35-d incubation period and 2 d between laying of eggs has been assumed (Cade and Weaver 1976; P. Trefry, Canadian Wildlife Service, personal communication). The age-estimation is believed to be accurate to ± 3 d, and has been refined by documenting the development of known-age chicks on the study area (unpublished data). Therefore, abandonment of the initial clutch likely took place 9 to 14 d after initiation of laying, and 5 to 10 d after the start of continuous incubation (beginning with the penultimate egg).

Ratcliffe (1980) pointed out that most Peregrines will initiate replacement clutches if incubation has not proceeded longer than 7 to 10 d. Beyond 10 d the probability of renesting decreases rapidly, although there are documented cases of successful replacement clutches started after the initial clutch had been incubated to term (Morrison and Walton 1980).

Similar back-dating techniques placed the initiation of the replacement clutch at 7 June. Thus, approximately 16 d (the recycling period) elapsed between termination of incubation and effective abandonment, and the laying of the first egg of the replacement clutch. This compares with the 14-d period reported for most falcons by Cade (1982). Prairie Falcons (*F. mexicanus*), closely related taxonomically to the Gyrfalcon (Cade 1982), had a mean recycling time of 16 d ($n = 12$) (Morrison and Walton 1980). Ratcliffe reported a mean recycling time of 19 to 20 d for 43 cases of relaying in Peregrine Falcons in England. A mean recycling period of 16 d (range 15 to 17 d, $n = 5$) was noted in captive Gyrfalcons (P. Trefry, personal communication).

Renesting in Gyrfalcons has been documented in captivity (Platt 1977; P. Trefry, personal communication), but little has been published on this behaviour in wild birds. In an extensive review of replacement clutches in North American raptors, Morrison and Walton (1980) did not mention the Gyrfalcon. Referring to wild birds, Cade (1960: 206) stated "if a first clutch is lost, Gyrfalcons can lay a second set with a reasonable chance for survival of the young", but only cited one case, in the Alaskan Range (latitude approximately 63°N). Platt (1976) reported two successful Gyrfalcon renests on the Yukon North Slope (69°N). Kuyt (1980) suggested renesting in Gyrfalcons may also occur in the Thelon River area, N.W.T. (64°N), citing the wide range in estimated dates of laying (20 April to 2 June). In an extensive 5-yr study of Gyrfalcons in Iceland (66°N), no renesting was observed despite 12 documented reproductive failures at the egg stage (Nielsen 1986).

The two chicks from the renest reported here were about 26 d behind the rest of the population, with predicted fledging in the last days of August compared with the average of early August. Because of the late fledging date the period between fledging and independence, believed to be 4 to 6 wk in Gyrfalcons (Cade 1982), may by necessity have been shortened. As the weather worsens and daylength shortens, prey densities diminish. If, as on the Yukon North Slope (Platt 1976), the juvenile falcons move south and the adults remain in the nesting area, the shortening of this "learning" period could reduce the probability of survival in late-fledging birds.

Gyrfalcons nest up to 82°N latitude in Greenland and arctic Canada (Cade 1982). There are no reports known to me of renesting north of 70°N in North America or the European arctic,

although this may be more a function of little research in these northern regions than an absence of the behaviour. It seems likely, as pointed out by Newton (1979), that fewer cases of renesting would occur in high arctic populations with shorter summer seasons and little flexibility in the time available to fledglings to learn skills necessary for independent life.

Renesting would enable pairs to attempt production of young if the initial clutch was predated, frozen, buried by snow or, as in this case, abandoned due to disturbance. However, because of the relatively long period from initiation of laying to independence of young, we would expect less renesting in Gyrfalcons than other smaller species, and selection against the behaviour if the mortality of renesting adults was higher and survival of the young lower than usual. Telemetry or other detailed studies would be required to determine if the survival of Gyrfalcon fledglings produced from renest clutches is lower than earlier fledging birds, and the relative cost to adults of renesting versus waiting to reproduce in the next year.

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Southern Bog Lemming, *Synaptomys cooperi*, New to Islands in Lake Michigan

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Long, Charles A., and John Edward Long. 1988. Southern Bog Lemming, *Synaptomys cooperi*, new to islands in Lake Michigan. *Canadian Field-Naturalist* 102(1): 64-65.

The first record of Southern Bog Lemmings on islands of Lake Michigan is reported. These mice, which have white feet, are found on Washington and Rock islands.

Key Words: Southern Bog Lemming, *Synaptomys cooperi*, Wisconsin, Lake Michigan.

Although numerous studies have been carried out on the islands in Lake Michigan, microtine voles have been seldom trapped on any of them (Long 1974; Hatt et al. 1948; Burt 1948; Baker 1983; Jackson 1961). The Red-backed Vole, *Clethrionomys gapperi*, occurs on Washington, Poverty (Long 1978) and Beaver islands (see Ozoga and Phillips 1964). The Meadow Vole, *Microtus pennsylvanicus*, is abundant surrounding Lake Michigan but is known only from one specimen taken near a bog on Chambers Island (Long 1978), another taken on Summer Island (Nellis 1970), another collected in a small local population on Marion Island (Scharf 1984), and another obtained on North Manitou Island (Scharf and Jurac 1980).

Southern Bog Lemmings, *Synaptomys cooperi*, have never been taken on any island, and in three studies (see Johnson 1978) remain unknown from the Door Peninsula, and, across the Door of Death, on Washington Island. Southern Bog Lemmings are rarer than Meadow Voles and are possibly restricted to local populations by them (Getz 1961). The failure to obtain Southern Bog



FIGURE 1. Map showing islands where Southern Bog Lemmings were collected within the Lake Michigan drainage basin.

Lemmings on the sands, cobbles, limestone ledges, and limy soils of Chambers Island and all the isles across Green Bay was not surprising (Long 1978). However, Tom Jessen, a park ranger who is in charge of Rock Island State Park, found one dead on the grassy lawn there. Previous and subsequent trapping has revealed no other Southern Bog Lemmings from Rock Island.

Rock Island is separate by only $\frac{1}{4}$ - $\frac{1}{2}$ mile (0.4-0.8 km) of water from the north shore of Washington Island, which is ecologically similar (beech, maple, cedars, sedge meadows). Subsequent field work focused on sedge meadows reveals several local populations on the north side of Washington Island. Nine additional bog lemmings were collected. All specimens are deposited in the University of Wisconsin Museum of Natural History in Stevens Point (6250-6259).

Old fields, prairies, marshes, and bogs are common throughout Washington Island, seemingly suitable for Meadow Voles, which are strangely absent. Perhaps their absence is related to the Southern Bog Lemming's presence. The Southern Bog Lemmings collected are interesting in that they have conspicuous white feet.

Acknowledgments

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A New Ontario Locality Record for the Crayfish *Orconectes rusticus* from West Duffin Creek, Durham Regional Municipality

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Maude, Stephen H. 1988. A new Ontario locality record for the crayfish *Orconectes rusticus* from West Duffin Creek, Durham Regional Municipality. *Canadian Field-Naturalist* 102(1): 66-67.

A new Ontario locality record is described for *Orconectes rusticus* (Girard), an introduced crayfish species, from West Duffin Creek, Durham Regional Municipality. Collections consisted of one adult female and one form I male in 1983, and an additional form I male in 1985. Other crayfish species collected in the Duffin Creek watershed were *O. propinquus*, *O. virilis* and *Cambarus robustus*. The demonstrated ability of *O. rusticus* to expand its range and displace native crayfish species is discussed.

Key Words: crayfish, *Orconectes rusticus*, southern Ontario, West Duffin Creek, introduction, range expansion.

Orconectes rusticus (Girard) is a crayfish species native to the midwestern United States which has been introduced into Ontario, presumably through use as fishing bait (Crocker and Barr 1968). As recently as the mid-1960s, when the Ontario crayfish species' distributions were reviewed by Crocker and Barr (1968), *O. rusticus* was considered rare in the province, being reported from only six localities. However, since that time *O. rusticus* has expanded its range dramatically. In the Kawartha Lakes region, *O. rusticus* has now replaced the native *O. propinquus* as the most abundant crayfish species (Berrill 1978; Berrill and Arsenault 1984).

Duffin Creek drains a 294 km², predominantly rural watershed located east of Metropolitan Toronto. It comprises two major branches which are confluent 8 km upstream from Lake Ontario. The smaller of the two, West Duffin Creek, flows 38 km from its source north-east of Stouffville to the confluence at a gradient of 6.6 m/km.

Adults of *O. rusticus* were collected by seine from West Duffin Creek near Stouffville, (Durham Regional Municipality; 43°57.1'N, 79°11.1'W; Figure 1). Adult male crayfish alternate between two distinct forms, form I and form II. Form I is the sexually competent form and is characterized by a more robust exoskeleton and heavier chelipeds than form II. One form I male, carapace length 29 mm, and one female, carapace length 25 mm, were collected on 23 August 1983. These specimens are catalogued at the Royal Ontario Museum (Catalogue Number: ROMIZ L 3507). Two years later, on 17 September 1985, one form I male was collected, carapace length 24 mm.

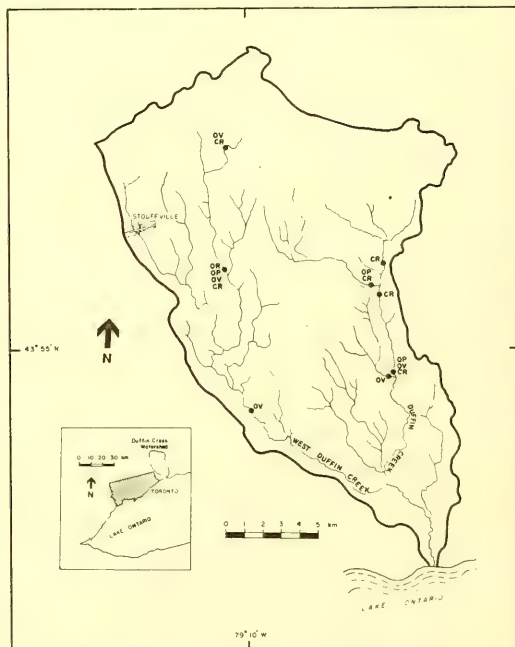


FIGURE 1. Locations of crayfish collections in the Duffin Creek watershed, 1980 - 1985. OR - *Orconectes rusticus*, OP - *Orconectes propinquus*, OV - *Orconectes virilis*, CR - *Cambarus robustus*.

The Metropolitan Toronto and Region Conservation Authority has developed and monitored a fisheries enhancement project at this collection site

over the past several years. At this point, West Duffin Creek is a third-order stream approximately 5 m wide with a predominantly gravel/cobble substrate. The creek is shaded by Eastern White Cedar (*Thuja occidentalis*). Pastured livestock have access to some portions of the creek. *Orconectes propinquus*, *O. virilis*, and *Cambarus robustus* were also found at this location between 1982 and 1985. These three species occurred in other, albeit cursory, collections made within the Duffin Creek watershed since 1980, but *O. rusticus* was absent (Figure 1).

Perhaps owing to their use as bait by fishermen (Capelli 1982; Page 1985), crayfish have often been introduced outside their natural ranges where, in many cases, they have flourished at the expense of indigenous species (e.g. Schwartz et al. 1963; Smith 1979; Daniels 1980).

Crocker and Barr (1968) indicated that the introduced *O. rusticus* was replacing *O. virilis* in Long Bay, Lake of the Woods in northwestern Ontario. To date it has spread about 5 km through Long, Lobstick and Regina Bays to Sioux Narrows. Throughout the area where it is found the native *O. virilis* is absent (Frederick W. Schueler, personal communication). *Orconectes rusticus* has effectively eliminated *O. virilis* from the Pigeon River, Michigan (Momot et al. 1978) and is apparently displacing *O. propinquus* and *O. virilis* in nine lakes in northern Wisconsin, although displacement rates were found to be highly variable among the lakes (Capelli 1982). In contrast, since its introduction into Trout Lake, Wisconsin, *O. rusticus* has remained in low abundance relative to *O. propinquus* and *O. virilis* (Lodge et al. 1986). These authors suggest that the outcomes of interspecific interactions vary. Clearly, many ecological and behavioural factors are involved (Capelli and Capelli 1980; Capelli and Munjal 1982; Maude and Williams 1983; Berrill 1985).

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Common Raven, *Corvus corax*, Caching Food in Snow

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Kilham, Lawrence. 1988. Common Raven, *Corvus corax*, caching food in snow. *Canadian Field-Naturalist* 102(1): 68.

A Common Raven (*Corvus corax*) when alone, buried a heavy scrap of bone plus fat in snow, then covered it over with sweeping motions of its bill. Other presumed raven caches were found nearby.

Key Words: Common Raven, *Corvus corax*, caching, New Hampshire.

Although Bent (1946), Turcek and Kelso (1968), and Knight and Call (1980) mention Common Ravens, *Corvus corax*, storing food, and both Gwinner (1965) and Kilham (in press) have made repeated observations of their doing so in captivity, I have encountered no detailed reports of their storing food in the wild, other than one by Simmons (1970) of a raven storing food in Tunisia, and none of storing food in snow. The following observations of a raven caching food in snow were made on a farm in Lyme, New Hampshire, where I started a feeding station in November 1985. Five American Crows, *Corvus brachyrhynchos*, and a pair of ravens that always came from the north were regular visitors. Late on the morning of 17 December a single raven, one that left to the south, was present. It flew with a sizeable item in its bill for 25 m, then dropped into 18 cm of powder snow. Without moving from where it landed, it tossed snow with sweeping motions of its bill. After working for a minute with its head in the hole it flew away. On inspection I found a basin shaped depression the size of the raven's body. After scraping away 5 cm of snow I uncovered a scrap of bone and suet 6-7 cm in diameter.

A single raven, I believe the same one for it flew on the same course to the south, was alone at the feeding station on the following morning. This time it flew to a depression 15 m away where it put its head down, held its bill up as if eating something, then flew to a second raven-sized depression farther on. It worked here for a minute, then left. I found nothing in the first depression and a slab of ribs, meat and suet covered with snow in the second one. The slab measured roughly 12 × 19 × 3 cm. Fresh snow had fallen three days before and I could see, by an absence of tracks, that no bird or mammal had come within 10-15 m of any of the depressions. The items stored were larger and heavier than anything that I have observed being carried by crows.

Lorenz (1970), in observations on the food storing of four species of hand-raised corvids, noted that only ravens took care not to be seen by conspecifics or other animals when hiding food. The raven that I observed caching food was unusual in being at the feeding station alone. It is

conceivable that wild ravens cache food more often than is commonly realized, but being circumspect in the way they do it, are more difficult to observe than American Crows (Kilham 1984, 1985). The habit of storing food is common in corvids (Goodwin 1976), but only the Black-billed Magpie, *Pica pica*, (Summers-Smith 1984) and the American Crow (Kilham, in press) have hitherto been reported caching food in snow, both species poking it in with the bill.

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Yellow-billed Loons, *Gavia adamsii*, Nest Successfully Near Glaucous Gull, *Larus hyperboreus*, Nests

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North, Michael R., and Mark R. Ryan. 1988. Yellow-billed Loons, *Gavia adamsii*, nest successfully near Glaucous Gull, *Larus hyperboreus*, nests. *Canadian Field-Naturalist* 102(1): 69–70.

Three pairs of Yellow-billed Loons (*Gavia adamsii*) nested successfully near Glaucous Gull (*Larus hyperboreus*) nests in both 1983 and 1984 on the Colville River delta, Alaska (70°20' N, 150°45' W). Yellow-billed Loon pairs that nested near Glaucous Gulls had a larger mean brood size than other pairs in 1983. Yellow-billed Loons and Glaucous Gulls may benefit mutually by nesting near alert neighbors.

Key Words: Yellow-billed Loon, *Gavia adamsii*, Glaucous Gull, *Larus hyperboreus*, nest success, Alaska.

Larids are major predators of Common Loon, *Gavia immer*, eggs and chicks (Olson and Marshall 1952; Fox et al. 1980; McIntyre 1983) and Pacific Loon (*G. pacifica*, formerly *G. arctica pacifica*, A. O. U. 1985) eggs (Bergman and Derksen 1977; Petersen 1979). Titus and VanDruff (1981) reported six negative Common Loon-Herring Gull, *Larus argentatus*, interactions. In one case a gull preyed on a loon nest 25 m from its own nest. In five cases Common Loons did not attempt to renest after Herring Gulls built nests on the same islands. Although little information is available on interactions with gulls, Yellow-billed Loons, *G. adamsii*, may be less susceptible to gull predation than other loons. Neither Sage (1971) nor Sjolander and Agren (1976) reported nest losses to gulls. On the Colville River delta we observed three Yellow-billed Loon pairs which successfully nested near Glaucous Gull, *L. hyperboreus*, nests.

Associations with larids enhanced waterfowl (Vermeer 1968; Evans 1970) and grebe (Nuechterlein 1981) nest success because larids drove away potential predators and alerted others with their alarm calls. Vermeer (1968) found that waterfowl nesting in association with predaceous gulls had high nesting success, but that the gulls depredated most broods.

We studied the breeding biology of Yellow-billed Loons on the Colville River delta (70°20' N, 150°45' W), 260 km southeast of Barrow, Alaska. The 575-km² delta is one of the few areas in North America where concentrations of breeding Yellow-billed Loons occur. Field studies were conducted from 12 May to 15 August 1983 and 15 May to 29 August 1984. Nests were found by searching lakeshores and by observing pairs on lakes. Each year we checked 17 nests every one to three days, from a week before the expected hatch date until

hatch occurred, to determine nest success. Brood counts were obtained from 17 pairs on 6 to 12 August 1983, and from 17 pairs on 17 to 20 August 1984.

Three Yellow-billed Loon pairs nested near Glaucous Gulls. Yellow-billed Loons and Glaucous Gulls were very alert to potential dangers during the breeding season. Gulls always harassed humans within 200 m and frequently within 300 m of their nests or broods. Loons were usually aware of potential dangers over similar distances. Having alert neighbors may be advantageous to both species.

One Yellow-billed Loon pair nested 30 m from a gull nest; they raised two chicks in 1983. In 1984, loons nesting at the same site (we assume the same pair) hatched two eggs but lost both chicks, at least one to a Glaucous Gull when our activities caused the adult loon and chick to become separated. Three gulls, including two with a nest nearby, were harassing us. One gull swooped down and took the loon chick present, but we do not know if that gull was a member of the nest pair. The gull pair hatched young both years.

Another Yellow-billed Loon pair nested 96 m from a gull nest. They raised two chicks in 1983 and one chick in 1984. The gull pair hatched young at least one year. Another loon pair nested on a lake which had a colony of 20 to 30 resident gulls. The loons nested on an island 100 m from an island which contained three or more gull nests. The loons raised two chicks in 1983 and one chick in 1984. We did not determine gull nest success at that lake. Two other Yellow-billed Loon pairs nested approximately 100 m from Arctic Terns, *Sterna arctica*.

Only three negative loon-gull interactions were observed. One was the incidence of predation

described previously. Another incident involved the loon pair nesting near the gull colony. One member of the pair was loafing on the water about 10 m from the nest when a gull landed 1 m from the unattended nest. The loon rushed towards the gull, which immediately took off. The only loon-gull interaction involving a loon pair not nesting in association with gulls occurred when a non-incubating loon rushed at a gull that was on shore 500 m from the nest.

Success of Yellow-billed Loons nesting near Glaucous Gulls was not substantially higher than for the remaining population. Thirteen of 14 loon nests (92.9%) not associated with gulls hatched at least one egg in both 1983 and 1984. Only the nest lost in 1984 was probably the result of avian predation. Other common avian predators on the delta were Parasitic, *Stercorarius parasiticus*, and Long-tailed jaegers, *S. longicaudus*, and Common Ravens, *Corvus corax*.

Although sample size was too small to be analyzed statistically, loon pairs that nested near gulls had larger broods than the rest of the Yellow-billed Loon population in 1983. In 1983, the three loon pairs each raised 2 chicks, whereas mean brood size of 13 other Yellow-billed Loon pairs that hatched young was 1.2 chicks. In 1984, the numbers of young raised by the two Yellow-billed Loon pairs that nested near gulls (excluding the pair that lost its last chicks because of our interference) were identical to the mean brood size of the 14 other pairs (1.0 chick per pair that hatched young).

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Hornseed Buttercup, *Ceratocephalus testiculatus*: A New Record for the Adventive Flora of Saskatchewan

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Cody, W. J. 1988. Hornseed Buttercup, *Ceratocephalus testiculatus*: a new record for the adventive flora of Saskatchewan. *Canadian Field-Naturalist* 102(1): 71-73.

Hornseed Buttercup (*Ceratocephalus testiculatus*) is reported as new to the adventive flora of Saskatchewan. A description of the plant, an illustration, and a distribution map are provided. Comments are made on the occurrence of this taxon in British Columbia, the northwestern United States and Eurasia. Because this taxon is sometimes included in the genus *Ranunculus*, characteristics which separate *Ceratocephalus* from *Ranunculus* are provided. A closely related species, *C. falcatus*, also occurs in Eurasia; characters which distinguish it from *C. testiculatus* are provided.

Key Words: Hornseed Buttercup, *Ceratocephalus testiculatus*, *Ranunculus testiculatus*, Ranunculaceae, Saskatchewan.

A number of specimens of a small plant that had been collected in the town of Assiniboia, Saskatchewan, were forwarded by Saskatchewan government personnel to the Canada Agriculture Research Station at Regina. Because this plant was not known to the staff at the Regina station, it was in turn forwarded to the Biosystematic Research Centre in Ottawa for identification. After close examination and comparison with specimens preserved in the Vascular Plant Herbarium, it was found to be Hornseed Buttercup, *Ceratocephalus testiculatus*, a member of the family Ranunculaceae. The species is new to the adventive flora of Saskatchewan. Data are as follows:

SASKATCHEWAN, Assiniboia, many plants found growing profusely in boulevard and seeming to be out-competing grass, *A. Olsen s.n.*, 26 May 1986 (DAO); *idem* 21 April 1987 (DAO).

Ceratocephalus testiculatus is a Eurasian species which Tutin (1964) reported as occurring in cultivated fields and waste places in east-central and southeastern Europe. In the northwestern United States, Hitchcock and Cronquist (1964) (in the entry under *Ranunculus testiculatus*), report, "This recently introduced Eurasian species has spread rapidly throughout n.w. U.S., e. of the Cascades especially in sagebrush; e. Wash. and Oreg. e. to Nev., Ida., and Colo." In Canada, Taylor and MacBryde (1977) indicate the species is rare, occurring in Ponderosa Pine - Bunchgrass associations. However, label data on six specimens collected in British Columbia and preserved in the Agriculture Canada Vascular Plant Herbarium, the University of British Columbia Herbarium, and the British Columbia Provincial Museum

Herbarium between 1953 and 1986 indicate that the species is locally common in that province and seems to be spreading.

Data for the six specimens are as follows: Oliver, collected in the camp ground of Mrs. Delaney where it is apparently thriving in traffic areas and dry regions of the grounds, *J. E. Miltimore*, May 1968 (DAO); Harper Ranch about 8 miles east of Kamloops. Locally common on grassy hillside by road. *Calder & Savile 8584*, 2 June 1953 (DAO); rocky ledges above Vaseau Lake, Apex Rd., Similkameen Dist., 49°02'N, 119°30'W, *A. A. Rose 8190*, 16 May 1981 (UBC); Tranquille, north side of Kamloops Lake on a dry sagebrush hillside, *J. Herriot s.n.* 27 April 1986 (UBC); Paul Creek Valley, N.E. of Kamloops on Scheidam Flats, along the road with Sagebrush, abundant, *D. St. John s.n.*, 27 April 1986 (UBC); Cache Creek beside old Cariboo Hy. at N end of I.R. #3, overgrazed Range Cheatgrass with Sagebrush-Bluebunch-Wheatgrass, *Bawtree & Tegart*, 18 May 1978 (V).

Ceratocephalus testiculatus is a small scapose, more or less tomentose, annual that flowers and fruits early in the season (April to June). The leaves are all basal, 1.5 to 4 cm long, ternate to biternate, the linear divisions about equal in width to the broad petiolar base. The several peduncles are leafless, 2 to 8 cm tall, and each bears a single inconspicuous flower. The 4 to 6 greenish, 4 to 6 mm long, ovate-lanceolate sepals persist long after anthesis. The usually 5, narrow, 5-to-8-mm-long petals are white, with pinkish veins. The fruiting heads are almost bur-like when dry and mature (Figure 1). The achenes, 25 to 70 in



FIGURE 1. Photograph of a specimen of Hornseed Buttercup (*Ceratocephalus testiculatus*) from San Pete County, Utah (DAO).

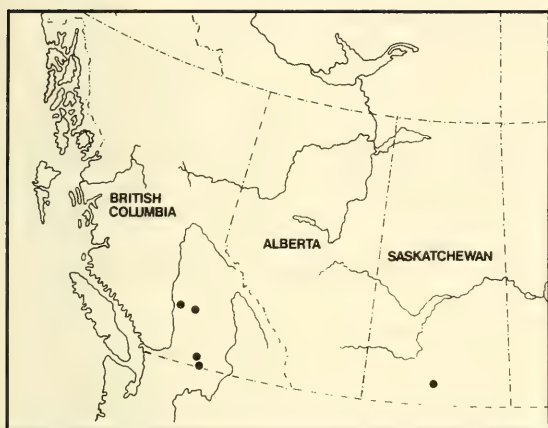


FIGURE 2. Known Canadian distribution of Hornseed Buttercup (*Ceratocephalus testiculatus*).

number, are borne in a cylindrical cluster which measures up to 15 mm or more in length. The achenes bulge on the ventral (upper) side into two blister-like vesicles, then narrow into a lanceolate, laterally compressed, setose-tipped, straight beak 3 to 4 mm long. Each achene contains a single seed in the basal portion.

As noted above, species in the genus *Ceratocephalus* are sometimes included in the genus *Ranunculus* (Boivin 1966; Hitchcock et al. 1964). *Ceratocephalus* may be distinguished from *Ranunculus* by the achenes which have an empty cell on either side of the seed and by the acuminate, more or less up-curved beak which is 2 to 3 times as long as the body of the achene (Tutin 1984). Another species of *Ceratocephalus*, which is also found in similar habitats in southern Europe and adjacent regions, is *C. falcatus*. It may readily be separated from *C. testiculatus* by its broader and distinctly falcate beak. It has not yet been reported from North America.

Hornseed Buttercup is not yet widespread in Canada (Figure 2), but may become so in the drier regions of the western provinces. Where it does occur, it appears to be well-established and has the potential for becoming an annoying weed.

Acknowledgments

The author is indebted to Cynthia Durance, Vascular Plant Herbarium, Department of Botany, University of British Columbia, and Lesley M. Kennes, Herbarium Administrator, British Columbia Provincial Museum, for the loan of specimens and information on recent collections in British Columbia. Herbarium acronyms are according to Holmgren et al. (1981).

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Moose, *Alces alces*, Calf Mortality in New Brunswick

ARNOLD H. BOER

Fish and Wildlife Branch. P. O. Box 6000, Fredericton, New Brunswick E3B 5H1 and Department of Forest Resources, University of New Brunswick, Fredericton, New Brunswick E3B 6C2

Boer, Arnold H. 1988. Moose, *Alces alces*, calf mortality in New Brunswick. *Canadian Field-Naturalist* 102(1): 74-75.

Eleven Moose (*Alces alces*) calves (≤ 3 days old) were fitted with radio collars and monitored through their first year of life. Mortality rate for calves in their first six months of life was estimated at 25-35%.

Key Words: *Alces alces*, Moose, mortality, neonates, New Brunswick, predation.

Neonates are the single most numerous ungulate cohort at parturition, and their mortality rate is of concern to wildlife managers since it ultimately determines recruitment rates of the breeding population. Predation is an important cause of Moose (*Alces alces*) calf mortality in North America (Wolfe 1977; Franzmann et al. 1980; Ballard et al. 1981; Crête et al. 1981; and Gasaway et al. 1983). Franzmann et al. (1980) and Ballard et al. (1981) documented the causes of Moose calf mortality in early life by capturing calves ≤ 3 days old and affixing mortality-sensitive radio transmitters. This paper reports the results of a similar study in New Brunswick near the southern limit of Moose range where the only major predator is the Black Bear (*Ursus americanus*).

Study Area

The Lake Stream study area, 2396 km², is in the Maritime Lowland Ecoregion (Loucks 1962) in southeastern New Brunswick (46° 15'N, 65° 30'W). Jack Pine (*Pinus banksiana*) is prominent on sandy sites; Black Spruce (*Picea mariana*) swamps and peat bogs cover extensive areas of poorly drained soil. Red Spruce (*P. rubens*), Balsam Fir (*Abies balsamea*), Red Maple (*Acer rubrum*), Hemlock (*Tsuga canadensis*), and White Pine (*P. strobus*) are common on well-drained areas. Elevations on the gently undulating plain are 30 to 122 m.

Methods

Young calves (≤ 3 days old) were captured during late May and early June in 1984 and 1985 using methods described by Ballard et al. (1979). Calves were located from a Bell 206 Jet Ranger helicopter with two observers and the pilot. Searching activity was concentrated around openings in forest cover — particularly the wooded fringe around sphagnum bogs and open marshy meadows characteristic of prime calving habitat

(LeResche 1968). Once we were on the ground, capture and processing took less than two minutes.

Calves were fitted with radio transmitters (Telonics Inc., Meza, Arizona) equipped with mortality sensors (pulse doubled when movement ceased for four hours) sewn into an elastic collar patterned after Schwartz et al. (1983). The seam holding the collar together was sewn with a light cotton thread which, after weathering and with pressure from the expanded elastic, was expected to break away within one year. To minimize chances of calf abandonment following handling, assembled collars were hung outside for two weeks and then packaged individually in plastic bags. Rubber gloves were worn when handling the collars and calves.

Calves were monitored daily from fixed-wing aircraft during June, every two days in July, twice weekly in August, and weekly in September. Animals were located periodically thereafter until all transmitters had failed.

When mortality was suspected the collar was located as soon as possible. If the calf had been killed, criteria for determining cause of death followed those of Ballard et al. (1979).

Results and Discussion

Eleven of 23 located calves were captured and radio-collared. The Lake Stream study area is densely forested, especially near the wet habitats where most of the search for calves occurred. Thick cover and low density of moose contributed to the low observation and capture rates (48%).

Two of 11 collared calves were found dead (one each year). One calf was killed by a Black Bear when approximately three weeks old; the other was found dead at age 6 1/2 months. Three *Parelaphostrongylus tenuis* nematodes were found in the cranium of this second Moose, one lying on top of the brain and two in the ventral aspect of the cranial vault. This animal was emaciated and femur marrow fat was estimated (Neiland 1970) at 9%.

Importance of predation on Moose neonates varies widely. Black Bears are a significant predator of Moose calves < two months of age over much of their shared range (Franzmann et al. 1980). Black Bears are common in New Brunswick and some 800 to 1000 are killed each year in spring and fall. Predation rates may, in part, depend on predator and prey density, and habitat. In New Brunswick, low Moose densities and widely dispersed calving sites probably reduce the opportunity for interaction between bears and calves.

The interrelationship between White-tailed Deer (*Odocoileus virginianus*), *P. tenuis*, and Moose is not clear. Experimentally infected Moose exhibit clinical manifestations of *P. tenuis* infection and die (Anderson 1964), but Moose can successfully cohabit areas frequented by deer carrying the parasite (Irwin 1975). Deer harvests, and, presumably, numbers of deer have increased dramatically over the period 1973-1984 in the New Brunswick counties encompassing the study area (A. H. Boer, unpublished data). Density of deer in autumn is now estimated at 2/km² (A. H. Boer, unpublished data). Despite this increase, there has been no corresponding increase in reported or suspected cases of *P. tenuis* infection in Moose. Moose populations have remained relatively stable (Boer 1987).

Death of calves due to accidents and unknown causes are largely density-independent, and, while magnitude might be expected to vary by area, a combined loss of 11% (average between Franzmann et al. (1980) and Ballard et al. (1981) seems appropriate for New Brunswick. Hunting mortality for calves was estimated at 6% (Boer 1987). Total loss of calves in the first six months of life in New Brunswick is probably between 25 and 35% (11% for accidents and unknown causes + 6% hunting loss + incidental predation and *P. tenuis* losses). Because sample sizes were small, conclusions about mortality rates are tentative. Winter mortality rates were not determined in this study but they are probably low, since southeastern New Brunswick has a maritime climate with relatively mild winter conditions.

Productivity of Moose in southeastern New Brunswick (1.12 fetus/adult female) compared favourably with that reported in other studies (Boer 1987), and calf mortality rates are low compared to those of other populations (Wolfe 1977; Ballard et al. 1979, 1981; Franzmann et al. 1980). Early calf mortality rate estimates of 25 to 35% for New Brunswick are not expected to drive Moose population dynamics. Moose populations in southeastern New Brunswick are probably shaped primarily by adult mortality rates.

Acknowledgments

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Breeding of the Rock Dove, *Columba livia*, in January at Edmonton, Alberta

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McGillivray, W. Bruce. 1988. Breeding of the Rock Dove, *Columba livia*, in January at Edmonton, Alberta. Canadian Field-Naturalist 102(1): 76-77.

On 14 January 1986 in Edmonton, Alberta, two Rock Doves, *Columba livia*, were found incubating single eggs. One egg was fertile. Both nest sites were sheltered from wind but not heated.

Key Words: Rock Dove, *Columba livia*, Edmonton, Alberta, breeding, winter.

Winter breeding of the Rock Dove, *Columba livia*, is not uncommon in milder parts of its range including much of Britain (Goodwin 1977), the east coast of the United States (Schein 1954; Preble and Heppner 1981), Pennsylvania (Dunmore and Davis 1963) and Kansas (R. F. Johnston, personal communication). In more continental climates, breeding commences in February or March (Flint et al. 1984). In Canada, there are few documented cases of winter breeding of Rock Doves; however, it probably occurs regularly in the Maritimes (A. J. Erskine, personal communication), southern Quebec and Ontario (Peck and James 1983) and southern British Columbia. At the high latitude site of Tampere, Finland (61° 30' N), pigeons have bred in mid-winter (Hakkinen et al. 1973). The birds nested in two factory lofts where the temperature was warmer than ambient, which for that winter (December and January 1972-73) averaged 5°C above the 30 year norms of -3.9°C (December) and -7.9°C (January).

During the winter of 1985-86 Rock Doves were acquired by staff of the Provincial Museum of Alberta and for the museum by Edmonton City Pest Control Officers for use in a morphometric study. Anecdotal evidence of winter breeding of Rock Doves in Edmonton (53° 40' N) was obtained from discussions with Bylaw Enforcement personnel. Hence, a search for active nests was initiated. On 14 January 1986, at two sites, pigeons were found incubating single eggs. One nest was located on the roof of an office building in downtown Edmonton; the nest was protected from wind but was exposed to ambient temperatures. The second nest was located on a metal support for a truck weigh-scale at a gravel yard. This site was also sheltered but not heated.

The egg (14.1 g) from the roof contained a developing embryo (1.9 g), but the second egg (15.2 g) was infertile, even though it was being

actively incubated. Ten of 12 males collected in December and January from the two sites had enlarged testes but none of the six additional females acquired showed active ovaries.

Table 1 shows that, in Edmonton, both December 1985 and January 1986 were mild relative to long-term averages, but mean temperatures of -5.0°C combined with extremely short daylengths are unusual conditions in which to find breeding birds. The inactive ovaries of the collected females and the fact that only two active nests were found suggest that winter breeding of Rock Doves is not regular in Edmonton even in a relatively mild winter. These observations indicate that an indoor nest site such as the one used at Tampere is not required for winter breeding of pigeons in sub-freezing temperatures.

The paucity of winter breeding records of Rock Doves in Canada may not mean that it is a rare event. It may be common in the milder parts of the country and may thus be unnoticed by ornithologists who as a group have virtually ignored the

TABLE 1. Temperature means¹ for December 1985 and January 1986 at Edmonton, Alberta, with long-term means.

	Temperature		
	Average Maximum °C	Average Minimum °C	Mean °C
December 1985			
Observed	-0.6	-9.1	-4.9
Average	-6.2	-14.5	-10.4
January 1986			
Observed	-0.8	-9.3	-5.1
Average	-10.7	-19.2	-15.0

¹Data from Environment Canada Monthly Meteorological Summaries — December 1985, January 1986.

natural history of urban pigeons (Goodwin 1977). This is unfortunate because these data indicate that even in Edmonton, Rock Doves have flexible clutch initiation dates. The phenology of avian breeding is still a subject of research (cf. Lack 1968; Immelmann 1973; Drent and Daan 1980) and further consideration of the environmental and genetic factors that determine pigeon breeding is warranted.

Acknowledgments

I would like to thank Tom McMinn and the Edmonton Bylaw Enforcement office for their efforts in locating nesting pigeons. Gloria C. Biermann improved the manuscript with her literature search and constructive comments. The comments of A. J. Erskine were greatly appreciated. Thanks to Colleen Steinhilber for her typing.

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New Brunswick Breeding of Wilson's Phalarope, *Phalaropus tricolor*, Confirmed

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McAlpine, Donald F., Mark Phinney, and Scott Makepeace. 1988. New Brunswick breeding of Wilson's Phalarope, *Phalaropus tricolor*, confirmed. *Canadian Field-Naturalist* 102(1): 77-78.

First New Brunswick breeding of Wilson's Phalarope, *Phalaropus tricolor*, was confirmed in the lower St. John River Valley in 1985. This eastward expansion of the known breeding range in Canada is part of a recent general extension of the breeding range in this country. Breeding in New Brunswick has been suspected for more than a decade.

Key Words: Breeding, New Brunswick, *Phalaropus tricolor*, Wilson's Phalarope.

Prior to the Second World War the breeding range of *Phalaropus tricolor* in Canada was confined to the prairie region. On the east coast the species was considered a rare to very rare spring and autumn transient (Taverner 1934). Since then, Wilson's Phalarope has undergone a dramatic expansion in breeding range to the west, north and east. This range expansion is graphically illustrated by comparison of the breeding range maps in the 1966 and 1986 editions of Godfrey's *Birds of Canada*. Currently the breeding range in North America is reported extending from coastal

British Columbia and the southern Yukon through the prairie provinces and north-central United States to northern Ontario, Quebec and south through the mid-west to Colorado, Arizona and central California with isolated breeding in Massachusetts [Plum Island] (American Ornithologists Union 1983; Godfrey 1986).

Breeding in the Maritimes has been suspected for more than a decade but has not previously been confirmed. It has been suggested the species arrival in the region, with several other "prairie species" (Gadwall, *Anas strepera*; Redhead, *Aythya*

americana; Ruddy Duck, *Oxyura jamaicensis*; and American Coot, *Fulica americana*), can be correlated with the appearance of artificial "prairie sloughs" in the form of Ducks Unlimited impoundments (A. J. Erskine, personal communication to DFM).

Here we document the first confirmed breeding of Wilson's Phalarope in the Maritimes. We also summarize other recent summer observations for this species in New Brunswick and Nova Scotia which suggest that breeding by Wilson's Phalarope, although rare and local, may be more widespread in southern portions of these two provinces.

While on Grassy Island, Kings County, New Brunswick (45°31'N, 66°04'W) 24 June 1986, Phinney and Makepeace observed a shorebird circling low near them and behaving in an agitated manner. They were unable to make a positive identification, but on the morning of the following day the three of us returned and were able to identify the bird as a Wilson's Phalarope.

As on the previous day the bird circled and wheeled near us, uttered agitated vocalizations, and at one point dropped to the ground and tried to lure us away with a broken-wing demonstration. We were convinced the bird was nesting and we searched the area carefully, locating three chicks. Unfortunately two of these were dead, apparently having been stepped on by one of us in our search. The two dead chicks were readily identified as Wilson's Phalarope based on published descriptions (Bent 1927; Harrison 1978) and have been placed in the bird collection of the New Brunswick Museum (NBM 6913, 6914).

Grassy Island (ca. 5 ha) is a low, flat, treeless island located 600 m offshore in the lower Saint John River. Little of the island is marshy but all of it is covered with grasses and forbs 10-50 cm in height with scattered tussocks of somewhat higher grasses. We located 21 Greater Scaup, *Aythya marila*, nests on the island and estimated about 100 pairs of Common Terns, *Sterna hirundo*, were also nesting on Grassy Island along with less than 12 Great Black-backed Gulls, *Larus marinus*, and undetermined numbers of Bobolink, *Dolichonyx oryzivorus*, and Savannah Sparrow, *Passerculus sandwichensis*. Small numbers of cattle are placed on the island during the summer.

Suspected breeding Wilson's Phalarope have been reported in New Brunswick for some years. P. A. Pearce observed a female in breeding plumage on the east bank of the Saint John River at Upper Gagetown ferry landing, Queens County, 15 May 1969 (about 50 km up river from Grassy Island). Pairs in breeding plumage have been reported on Saints Rest Saltmarsh, Saint John County by C. L. Johnston (10 June 1971), and J. Finne (June-July

1986) and at Sheffield, Queens County by N. Garrity (30 May 1984). Godfrey notes (1986) that Wilson's Phalarope may have bred in the Sackville area in 1978. Peter Barkhouse (Canadian Wildlife Service, personal communication to DFM) reports that two pairs of birds were observed on the marshes of Tintamar National Wildlife Refuge near Sackville during the four years 1978-1981. He notes that the birds behaved as if they were breeding, although neither nests nor young were seen. The observations of Barkhouse, as well as July sightings of *P. tricolor* at nearby Ram Pasture saltmarsh in 1983, 1984 and 1986 (A. J. Erskine, personal communication to DFM) all suggest that breeding may have occurred somewhere in the New Brunswick-Nova Scotia border area in each of these years.

In Nova Scotia Tufts (1986) reported that a female was seen on John Lusby Marsh, Cumberland County, on 5 July 1980, and a male and two juveniles were repeatedly observed there that year between 15 July and 9 August.

The above observations, in conjunction with a confirmed breeding record in New Brunswick, suggests that Wilson's Phalaropes may now be breeding rarely and locally in southern New Brunswick as far east as the Nova Scotia-New Brunswick border region.

Acknowledgments

We are grateful to those cited for sharing their observations of Wilson's Phalarope in southwestern New Brunswick with us. I. A. McLaren kindly provided details from the revised edition of the birds of Nova Scotia prior to its publication and A. J. Erskine provided useful comments on the manuscript.

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News and Comment

Notice of The Ottawa Field-Naturalists' Club 110th Annual Business Meeting 10 January 1989

The 110th Annual Business Meeting of the Ottawa Field-Naturalists' Club will be held in the auditorium of the Victoria Memorial Museum Building, Metcalfe and MacLeod streets, Ottawa on Tuesday, 10 January 1989 at 2000 h.

ROY JOHN
Recording Secretary

Call for Nominations for the 1989 Council of The Ottawa Field-Naturalists' Club

A nominating committee has been chosen by the Council to nominate persons for election to offices and membership of the Council for the year 1989, as required by the Constitution.

We would like to remind Club members that they also may nominate candidates as officers and other members of Council. Such nominations require the signatures of the nominator and seconder, and a statement of willingness to serve in the specified position by the nominee. Nominations should be sent to the Nominating Committee, The Ottawa Field-Naturalists' Club no later than 1 December 1988.

The Committee will also consider any suggestions for nominees which members wish to submit to it by 1 December 1988. It would be helpful if some relevant background on the proposed nominees were provided along with the suggested names.

BARBARA CAMPBELL
Chairman, Nominating Committee

The Ottawa Field Naturalists' Club, Post Office Box
3264, Postal Station C, Ottawa, Ontario K1Y 4J5

Call for Nominations for the 1988 Ottawa Field-Naturalists' Club Awards

Nominations are requested from Club members for the following awards:

Honorary Membership
Member of the Year Award
Service Award
Conservation Award
Anne Hanes Natural History Award

With the exception of honorary members all nominees must be members in good standing.

Nominations and supporting rationale should be submitted no later than 15 December 1988 to

Awards Committee

Description of these awards is given in *The Canadian Field-Naturalist* 96(3): 367(1982).

The Ottawa Field-Naturalists' Club, Post Office Box
3264, Postal Station C, Ottawa, Ontario K1Y 4J5

Baillie Fund Grants, 1988

The Trustees of the James L. Baillie Memorial Fund for Bird Research and Preservation decided to fund five bird projects in 1988. Three grants were directed at breeding bird atlas projects in Alberta, the Maritimes, and the Northwest Territories. The other grants were for ongoing

banding studies at Innis Point Bird Observatory in Ottawa, Ontario and to David Lemon for a study of Dark-eyed Juncos in Newfoundland. These grants represent the first for both Newfoundland and the Northwest Territories.

Baillie Fund Grants Available for 1989

The Trustees of the James L. Baillie Memorial Fund for Bird Research and Preservation welcome applications for grants for research in 1989. Projects involving research and/or conservation of birds in Canada will be considered, with a strong preference for applications from amateurs and others not eligible for grants from major academic funding sources. Graduate research studies are rarely supported, and only if they involve a major contribution by volunteer naturalists. Grants do not normally exceed \$1000.00. Applications for non-atlas research grants must be made on forms available from the Secretary, who must receive the completed application and supporting letters of recommendation by 31 December 1988. Applicants are advised to obtain the forms and guidelines well in advance. Because of the growing

number of breeding bird atlas projects in Canada, the Trustees have decided to establish a special category for remote travel grants for participants in such atlas projects. Potential applicants should enquire as to whether the atlas of their interest is participating. Application forms and guidelines are available from Martin K. McNicholl, Secretary, J. L. Baillie Memorial Fund. Tax-deductible contributions to the Fund are always welcome, and should be directed to the same address.

MARTIN K. McNICHOLL
Secretary

c/o Long Point Bird Observatory, P.O. Box 160, Port Rowan, Ontario N0E 1M0. Telephone: (519) 586-2909.

Dr. Stuart Houston Awarded Degree

Dr. Stuart Houston, head of the Department of Medical Imaging at the University of Saskatchewan, has been awarded a Doctor of Literature degree by the university — only the second time it has presented the award.

The university described Houston as a multitalented scholar with a distinguished record of publication in medicine, ornithology and the history of science. His medical studies have focused on such subjects as the adverse effects of smoking and the severity of lung disease in Indian children, while his work in ornithology has established him as a leading authority on the birds of Saskatchewan and the Central Plains region of Canada and the United States.

However, the university said his degree is more related to his historical research and writing, describing him as the world's foremost authority on the first John Franklin expedition of 1820. He has already edited two books on the subject, and a third is being prepared.

The university said Houston's degree was awarded "on the basis of scholarly activity of an outstanding nature as judged by three outside referees familiar with the candidate's work. The research requirements and the calibre of scholarly work are substantially in advance of what is accepted for a Ph.D."

The Blue Jay Newsletter May 1988

Rare and Endangered Fishes and Marine Mammals of Canada: COSEWIC Fish and Marine Mammal Subcommittee Status Reports: IV

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Campbell, R. R. *Editor*. 1988. Rare and endangered fish and marine mammals of Canada: COSEWIC Fish and Marine Mammal Subcommittee Status Reports: IV. *Canadian Field-Naturalist* 102(1): 81-86.

Twenty-four status reports, largely representing the 1987 fish and marine mammal status assignments, have been prepared for publication. Subcommittee activities are briefly discussed and species lists presented representing those animals for which reports are in progress and those for which reports are required.

Vingt-quatre rapports de statut représentant, pour le plus part, toute les données de statut aux poissons et aux mammifères marins nommés en 1987 ont été préparés pour publication. Les activités du sous-comité sont brièvement discutées avec des tableaux qui montre des rapports en cours et les espèces pour lesquelles on en a besoin encore.

Key Words: Rare and endangered species, fish, marine mammals, COSEWIC.

As indicated in previous submissions (Campbell 1984, 1985, 1987), the intent of the Subcommittee on Fish and Marine Mammals is to publish the status reports on fish and marine mammals which the Committee on the Status of Endangered Wildlife in Canada (COSEWIC) has reviewed, approved, and used as a basis of assigning status to species in jeopardy in Canada. The 24 reports represent the fish and marine mammal component of those species assigned COSEWIC status in 1987 or those for which the existing status was based on an updated report. In addition, the report on the Sea Mink (*Mustela macrodon*) has been included (status assigned April 1985) through the support of the Department of Fisheries and Oceans. Table 1 presents those species assigned status to April 1987. Due to the number of reports and the length of some they have been split between two issues. Twelve reports follow in this issue, the remainder will appear in *The Canadian Field-Naturalist* 102(2).

Progress

COSEWIC has undertaken to make available to all Canadians supporting information on each species classified (see Cook and Muir 1984). The Fish and Marine Mammal Subcommittee has been able to use this journal as one step in achieving the goal. A series of reports were published in 1984, 1985, and 1987 [see *The Canadian Field-Naturalist* 98(1): 63-133; 99(3): 404-450; 101(2): 165-309] and the encouraging response to these publications has provided the support for continued effort in this line.

The substantial number of reports handled in 1986/87 has reduced the backlog of status reports

in preparation or under review (Table 2) and also reduced the list of species awaiting consideration (Table 3). There remain 52 species of fish and 23 of marine mammals (Table 3) for which the Subcommittee desires status reports. Although some of these may be of no immediate concern, the Subcommittee will, as opportunity allows, attempt to document these species to determine their status in Canada.

There are currently 32 status reports on fish species, one on a marine mollusc and four on marine mammal species under review or in preparation (Table 2). Most of these should be assigned status in 1988. In addition to soliciting further status reports on species of concern, the Subcommittee has continued to obtain updates on the status of selected species as new information becomes available from independent studies. In the past year, for example, we received new information on the Gravel Chub (*Hybopsis x-punctata*) which confirmed that the species is extirpated from Canada (see Table 1). Other updated reports on the Narwhal (*Monodon monoceros*) and the Silver Shiner (*Notropis photogenis*) were considered with no change in status.

In 1986 a rare and endangered fish poster was also produced and copies are available from the Department of Fisheries and Oceans in Ottawa.

Concluding Remarks

The 24 reports included in the following series are reports on the status of the respective species in Canada. Status was assigned by consensus of the

TABLE 1. Fish and Marine Mammal Species with Assigned COSEWIC Status to April 1987.

Species	Scientific name	Status	Date assigned
Fish			
Lake Sturgeon	<i>Acipenser fulvescens</i>	NIAC'	April 1986
Blueback Herring	<i>Alosa aestivalis</i>	NIAC	April 1980
Green Sunfish	<i>Lepomis cyanellus</i>	NIAC	April 1987
Longear Sunfish	<i>Lepomis megalotis</i>	NIAC	April 1987
Lake Lamprey*	<i>Lampetra macrostoma</i>	Rare	April 1986
Green Sturgeon	<i>Acipenser medirostris</i>	Rare	April 1987
Shortnose Sturgeon	<i>Acipenser brevirostrum</i>	Rare	April 1980
Spotted Gar	<i>Lepisosteus oculatus</i>	Rare	April 1983
Squanga Whitefish*	<i>Coregonus</i> sp.	Rare	April 1987
Pacific Sardine	<i>Sardinops sagax</i>	Rare	April 1987
Silver Chub	<i>Hybopsis storeriana</i>	Rare	April 1985
Bigmouth Shiner	<i>Notropis dorsalis</i>	Rare	April 1985
Pugnose Shiner	<i>Notropis anogenus</i>	Rare	April 1985
Silver Shiner	<i>Notropis photogenis</i>	Rare	April 1983**
Pugnose Minnow	<i>Notropis emiliae</i>	Rare	April 1985
Redside Dace	<i>Clinostomus elongatus</i>	Rare	April 1987
Speckled Dace	<i>Rhinichthys osculus</i>	Rare	April 1980+
Central Stoneroller	<i>Camptostoma anomalum</i>	Rare	April 1985
Blackstripe Topminnow	<i>Fundulus notatus</i>	Rare	April 1985
Spotted Sucker	<i>Minytremma melanops</i>	Rare	April 1983
River Redhorse	<i>Moxostoma carinatum</i>	Rare	April 1983**
Brindled Madtom	<i>Noturus miurus</i>	Rare	April 1985
Giant Stickleback*	<i>Gasterosteus</i> sp.	Rare	April 1980
Unarmoured Stickleback*	<i>Gasterosteus</i> sp.	Rare	April 1983
Lake Simcoe Whitefish*	<i>Coregonus clupeaformis</i> spp.	Threatened	April 1987
Shortnose Cisco	<i>Coregonus reighardi</i>	Threatened	April 1987
Shortjaw Cisco	<i>Coregonus zenithicus</i>	Threatened	April 1987
Deepwater Sculpin	<i>Myoxocephalus thompsoni</i>		
Great Lakes Watershed		Threatened	April 1987
Elsewhere		NIAC	April 1987
Copper Redhorse*	<i>Moxostoma hubbsi</i>	Threatened	April 1987
Shorthead Sculpin	<i>Cottus confusus</i>	Threatened	Nov. 1983
Aurora Trout	<i>Salvelinus fontinalis timagamiensis</i>	Endangered	April 1987**
Acadian Whitefish*	<i>Coregonus canadensis</i>	Endangered	April 1983
Salish Sucker	<i>Catostomus</i> sp.	Endangered	April 1986
Gravel Chub	<i>Hybopsis x-punctata</i>	Extirpated	April 1987***
Paddlefish	<i>Polyodon spathula</i>	Extirpated	April 1987
Longjaw Cisco	<i>Coregonus alpenae</i>	Extinct	April 1985
Banff Longnose Dace*	<i>Rhinichthys cataractae smithi</i>	Extinct	April 1987
Blue Walleye	<i>Stizostedion vitreum glaucum</i>	Extinct	April 1985
Marine Mammals			
California Sea Lion	<i>Zalophus californianus</i>	NIAC	April 1987
Steller Sea Lion	<i>Eumetopias jubatus</i>	NIAC	April 1987
Atlantic Walrus	<i>Odobenus rosmarus rosmarus</i>		
Eastern Arctic		NIAC	April 1987
Northwest Atlantic		Extirpated	April 1987
Gray Whale	<i>Eschrichtius robustus</i>		
Northeast Pacific		NIAC	April 1987
Northwest Atlantic		Extirpated	April 1987
Hooded Seal	<i>Cystophora cristata</i>	NIAC	April 1986
Northern Elephant Seal	<i>Mirounga angustirostris</i>	NIAC	April 1986
Narwhal	<i>Monodon monoceros</i>	NIAC	April 1986**
Beaufort Sea Beluga	<i>Delphinapterus leucas</i>	NIAC	April 1986
Blue Whale	<i>Balaenoptera musculus</i>	Rare	April 1983

(Continued)

TABLE 1. Continued.

Species	Scientific name	Status	Date assigned
Fin Whale	<i>Balaenoptera physalus</i>	Rare	April 1987+
Sea Otter	<i>Enhydra lutris</i>	Endangered	May 1978°
Humpback Whale	<i>Megaptera novaeangliae</i>		
Northeast Pacific		Threatened	April 1982-
Northwest Atlantic		Rare	April 1985
Bowhead Whale	<i>Balaena mysticetus</i>	Endangered	April 1980°
Right Whale	<i>Eubalaena glacialis</i>	Endangered	April 1980*
St. Lawrence River Beluga	<i>Delphinapterus leucas</i>	Endangered	April 1983
Sea Mink	<i>Mustela macrodon</i>	Extinct	April 1985

*NIAC — Not in Any COSEWIC Category (i.e., not in jeopardy).

*Endemic to Canada.

+Updated April 1984 — no status change.

-Updated April 1985 — North Atlantic stock downlisted to Rare.

*Updated April 1985 — no status change.

°Updated April 1986 — no status change.

**Updated April 1987 — no status change.

***Updated April 1987 — previous status of Endangered assigned April 1985.

TABLE 2. Fish and Marine Mammal Species for which Status Reports are in preparation, or under review — April 1987.

Species	Scientific name	Proposed Status
Fish		
Darktail Lamprey	<i>Lethenteron alaskense</i>	Rare
Atlantic Sturgeon	<i>Acipenser oxyrhynchus</i>	?
White Sturgeon	<i>Acipenser transmontanus</i>	?
Atlantic Salmon	<i>Salmo salar</i>	?
Bering Cisco	<i>Coregonus laurettae</i>	?
Blackfin Cisco	<i>Coregonus nigripinnis</i>	Threatened
Bloater	<i>Coregonus hoyi</i>	Rare
Deepwater Cisco	<i>Coregonus johannae</i>	Endangered
Kiyi	<i>Coregonus kiyi</i>	Rare
Opeongo Whitefish*	<i>Coregonus</i> sp.	Threatened
Pygmy Whitefish	<i>Prosopium coulteri</i>	?
Pygmy Smelt	<i>Osmerus spectrum</i>	Rare
Hornyhead Chub	<i>Nocomis biguttatus</i>	Rare
River Chub	<i>Nocomis micropogon</i>	NIAC
Umatilla Dace	<i>Rhinichthys umatilla</i>	Rare
Redfin Shiner	<i>Notropis umbratilis</i>	Rare
Jasper Longnose Sucker*	<i>Catostomus catostomus lacustris</i>	Rare
Black Redhorse	<i>Moxostoma duquesnei</i>	Endangered
Greenside Darter	<i>Etheostoma blennioides</i>	?
Orangespotted Sunfish	<i>Lepomis humilis</i>	Rare
Striped Bass	<i>Morone saxatilis</i>	Endangered
Enos Lake Stickleback*	<i>Gasterosteus</i> spp.	Threatened
Bluefin Tuna	<i>Thunnus thynnus</i>	?
Marine Molluscs		
Northern Abalone	<i>Haliotis kamtschatkana</i>	?
Marine Mammals		
Bowhead Whale†	<i>Balaena mysticetus</i>	Endangered
Sowerby's Beaked Whale	<i>Mesoplodon bidens</i>	Rare
Cumberland Sound Beluga	<i>Delphinapterus leucas</i>	Threatened ?
Northern Quebec Beluga	<i>Delphinapterus leucas</i>	Endangered

*Endemic to Canada.

†Updated Status Report.

TABLE 3. Fish and Marine Mammal Species of Interest to COSEWIC (not by priority).

Species	Scientific Name	Possible Status
Fish		
Northern Brook Lamprey	<i>Ichthyomyzon fossor</i>	Rare (Ontario, Manitoba)
Chestnut Lamprey	<i>Ichthyomyzon castaneus</i>	Rare (Manitoba)
Bull Trout	<i>Salvelinus confluentus</i>	Rare (Alberta)
Red (Arctic) Char	<i>Salvelinus alpinus</i> ssp.	? (landlocked populations — Quebec, New Brunswick, Newfoundland/Labrador)
Lake Herring	<i>Coregonus artedii</i>	Endangered in Lakes Erie and Ontario but widespread elsewhere
Lake Whitefish	<i>Coregonus clupeaformis</i>	Threatened in Lakes Erie and Ontario but widespread elsewhere
Mira Whitefish*	<i>Coregonus</i> sp.	Rare (?)
Spring Cisco ¹ *	<i>Coregonus</i> sp.	Rare (Quebec)
Round Whitefish	<i>Prosopium cylindraceum</i>	Rare (Lakes Huron and Ontario but widespread elsewhere)
Pygmy Longfin Smelt*	<i>Spirinchus thaleichthys</i>	Rare (Landlocked population in Harrington Lake, British Columbia; anadromous populations widespread)
Chain Pickerel	<i>Esox niger</i>	Rare (Quebec)
Grass Pickerel	<i>Esox americanus vermiculatus</i>	Rare (Ontario, New Brunswick, Nova Scotia)
Redfin Pickerel	<i>Esox americanus americanus</i>	Rare (Quebec)
Bluntnose Minnow	<i>Pimephales notatus</i>	Rare (Manitoba)
Cutlips Minnow	<i>Exoglossum maxillingua</i>	? (Ontario, Quebec)
Eastern Silvery Minnow	<i>Hybognathus nuchalis regius</i>	Rare (Ontario, Quebec)
Western Silvery Minnow	<i>Hybognathus argyritis</i>	? (Alberta)
Blackchin Shiner	<i>Notropis heterodon</i>	Rare (Manitoba)
Ghost Shiner	<i>Notropis buchanani</i>	Rare (Ontario)
Rosyface Shiner	<i>Notropis rubellus</i>	Rare (Manitoba)
Striped Shiner	<i>Notropis chrysocephalus</i>	Rare (Ontario)
Weed Shiner	<i>Notropis texanus</i>	Rare (Manitoba)
Nooky Dace	<i>Rhinichthys cataractae</i> ssp.	Rare (British Columbia)
Leopard Dace	<i>Rhinichthys falcatus</i>	? (British Columbia)
Liard Hotspring Lake Chub*	<i>Couesius plumbeus</i> ssp.	Rare (British Columbia in the Liard Hotspring; normal form widespread elsewhere)
Mountain Sucker	<i>Catostomus platyrhynchus</i>	Rare (British Columbia, Alberta, Saskatchewan)
Lake Chubsucker	<i>Erimyzon sucetta</i>	Rare (Ontario)
Bigmouth Buffalo	<i>Ictiobus cyprinellus</i>	Rare (Ontario, Manitoba, Saskatchewan)
Black Buffalo	<i>Ictiobus niger</i>	? (Ontario)
Golden Redhorse	<i>Moxostoma erythrurum</i>	Rare (Ontario, Manitoba)
Flathead Catfish	<i>Pylodictis olivaris</i>	? (Ontario)
Banded Killifish	<i>Fundulus diaphanus</i>	Rare (Newfoundland, Manitoba; common elsewhere)
Margined Madtom	<i>Noturus insignis</i>	? (Québec)
Northern Madtom	<i>Noturus stigmos</i>	Rare (Ontario)
Brook Silverside	<i>Labidesthes sicculus</i>	? (Ontario)
Texada Stickleback*	<i>Gasterosteus</i> sp.	Rare
Redbreast Sunfish	<i>Lepomis auritus</i>	Rare (New Brunswick)
Warmouth	<i>Lepomis gulosus</i>	? (Ontario)
Eastern Sand Darter	<i>Ammocrypta pellucida</i>	Rare (Ontario)
Least Darter ¹	<i>Etheostoma microperca</i>	? (Ontario)
Tessellated Darter	<i>Etheostoma olmstedii</i>	Rare (Ontario)

Continued

TABLE 3. Continued.

Species	Scientific Name	Possible Status
Channel Darter	<i>Percina copelandi</i>	Rare (Ontario; Quebec)
River Darter ¹	<i>Percina shumardi</i>	Rare (Ontario)
Y-Prickleback	<i>Allolumpenus hypochromus</i>	Rare (British Columbia)
Cultus Pygmy Coastrange Sculpin*	<i>Cottus aleuticus</i>	Threatened (British Columbia)
Spoonhead Sculpin	<i>Cottus ricei</i>	Rare (Ontario)
Fourhorn Sculpin	<i>Myoxocephalus quadricornis</i>	Rare (Ontario)
Spinynose Sculpin	<i>Asemichthys taylori</i>	Rare (British Columbia)
Pixy Poacher*	<i>Ocella impi</i>	Rare (British Columbia)
Bering Wolffish	<i>Anarhichas orientalis</i>	Rare (Northwest Territories)
Blackline Prickleback	<i>Acantholumpenus mackayi</i>	Rare (Northwest Territories)
Marine Mammals		
Baird's Beaked Whale	<i>Berardius bairdii</i>	?
Northern Bottlenose Whale	<i>Hyperoodon ampullatus</i>	?
Sei Whale	<i>Balaenoptera borealis</i>	Rare (Northwest Atlantic)
Minke Whale	<i>Balaenoptera acutorostrata</i>	Rare
Sperm Whale	<i>Physeter catodon</i>	NIAC
Cuvier's Beaked Whale ¹	<i>Ziphius cavirostris</i>	?
Blainville's Beaked Whale ¹	<i>Mesoplodon densirostris</i>	?
Hubbs' Beaked Whale	<i>Mesoplodon carlhubbsi</i>	Rare
Stejneger's Beaked Whale	<i>Mesoplodon stejnegeri</i>	Rare
True's Beaked Whale ¹	<i>Mesoplodon mirus</i>	?
Long-finned Pilot Whale	<i>Globicephala melaena</i>	?
Killer Whale ¹	<i>Orcinus orca</i>	?
False Killer Whale ¹	<i>Pseudorca crassidens</i>	?
Harbour Porpoise ¹	<i>Phocoena phocoena</i>	?
Dall's Porpoise	<i>Phocoenoides dalli</i>	Rare
Atlantic White-sided Dolphin ¹	<i>Lagenorhynchus acutus</i>	?
Pacific White-sided Dolphin ¹	<i>Lagenorhynchus obliquidens</i>	?
White-beaked Dolphin ¹	<i>Lagenorhynchus albirostris</i>	?
Common Dolphin ¹	<i>Delphinus delphis</i>	?
Northern Right Whale Dolphin ¹	<i>Lissodelphis borealis</i>	?
Risso's Dolphin ¹	<i>Grampus griseus</i>	?
Striped Dolphin ¹	<i>Stenella coeruleoalba</i>	?
Bottlenose Dolphin	<i>Tursiops truncatus</i>	?

*Endemic to Canada.

¹Not of immediate concern.

COSEWIC Committee based on these reports which are published under the name(s) of the original author(s). The reports have undergone minor editing to provide a brief introduction and some degree of consistency in format and presentation.

Acknowledgments

First and foremost are our thanks to the various authors who have so generously contributed their time and talents in support of COSEWIC and to the members of the Subcommittee (see Campbell 1984) for their unstinting efforts in reviewing the reports and their helpful comments. The Subcommittee welcomes the addition of G. Stenson, Department of Fisheries and Oceans, St.

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The Subcommittee is grateful to World Wildlife Fund Canada, the Canadian Wildlife Service and the National Museum of Natural Sciences for their assistance in the process. A special mention to *The Canadian Field-Naturalist* for the assistance in publication and editing and to all members of COSEWIC for their dedication and interest in the future of Canada's flora and fauna. Last, but not least, we gratefully acknowledge the financial and secretarial support provided through the Department of Fisheries and Oceans.

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Status of the Aurora Trout, *Salvelinus fontinalis timagamiensis*, a Distinct Stock Endemic to Canada*

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Parker, B. J., and C. Brousseau. 1988. Status of the Aurora Trout, *Salvelinus fontinalis timagamiensis*, a distinct stock endemic to Canada. Canadian Field-Naturalist 102(1): 87-91.

Originally described as a distinct species, the Aurora Trout (*Salvelinus fontinalis timagamiensis*) was reclassified as a subspecies of Brook Trout (*Salvelinus fontinalis*) in the late 1960s. However, there remains disagreement concerning the validity of this classification within the scientific community. Some reviewers support the subspecies designation while others suggest that the Aurora Trout is not a valid subspecies and is only a distinct stock which has unique colouration. Historically, its distribution was limited to a small series of lakes in northeastern Ontario. The Aurora Trout probably disappeared from the wild in the early 1970s due to increased acidity of the original lakes resulting from acid rain and is now supported by hatchery stocks. In recognition of their importance as a stock of unique characteristics the Ontario Ministry of Natural Resources has developed an extensive management plan to rehabilitate the Aurora Trout.

D'abord décrit comme une espèce distincte, l'Omble de fontaine aurora (*Salvelinus fontinalis timagamiensis*) fut reclassifié parmi les sous-espèces de l'Omble de fontaine (*Salvelinus fontinalis*) à la fin des années 60. Pourtant il y a une discordance entre la validité de la classification dans la communauté scientifique. Quelques critiques viennent à l'appui de la classification comme les sous-espèces tandis que les autres donnent à penser que l'Omble de fontaine aurora n'est pas une véritable sous-espèce mais bien un stock distinct, dont la coloration est unique. Dans le passé sa distribution était limitée à une série de lacs du nord-est de l'Ontario. L'Omble de fontaine aurora à l'état sauvage est probablement disparu vers la fin des années 70 à cause de l'acidité des lacs originaux consécutif à la pluie acide et on ne le trouve plus maintenant qu'en pisciculture. En reconnaissance de son importance comme stock dont la composition et les caractéristiques sont uniques, le Ministère des richesses naturelles de l'Ontario a élaboré un plan de gestion exhaustif pour le rétablissement de l'Omble de fontaine aurora.

Key Words: Aurora Trout, *Salvelinus fontinalis*, salmonids, acid rain, char, northern Ontario, endangered fishes.

The Aurora Trout (*Salvelinus fontinalis timagamiensis*) is a distinct form of the Brook Trout (*Salvelinus fontinalis*) that is classified as endangered in Canada by loss of its natural habitat through pollution and acid rain. Maximum lengths at maturity are 45 to 55 cm, and weights of up to 3 kg (Figure 1) have been recorded. Colouration can be extremely variable, with a greenish to dark brown back, and often a few distinct spots are present on the sides. The caudal fin is characteristically square, indicating a similarity to Brook Trout. It is of considerable interest to the scientific community and important for its recreational value. The form has also been commonly referred to as the Aurora Char but is more closely related to the Brook Trout than to the Arctic Char (*Salvelinus alpinus*).

Distribution

The Aurora Trout was originally described as a distinct species from Whitepine Lake, Gamble Township, Ontario (47°23'N, 80°38'W). Naturally occurring populations were subsequently identified from three other lakes [Whirligig (47°23'N, 80°38'W), Aurora (47°21'N, 80°36'W), and Wilderness (47°22'N, 80°39'W)] in Gamble Township (Figure 2). During the late 1950s and 1960s the Aurora Trout populations in these lakes declined and by 1971 had disappeared. It was reported that prior to the disappearance of wild populations of Aurora Trout that Brook Trout were introduced and there had been hybridization (Sale 1967). Brood stock were maintained in an Ontario Ministry of Natural Resources (OMNR) hatchery. Since the early 1970s Aurora Trout have

*Endangered status approved and assigned by COSWIC 7 April 1987.

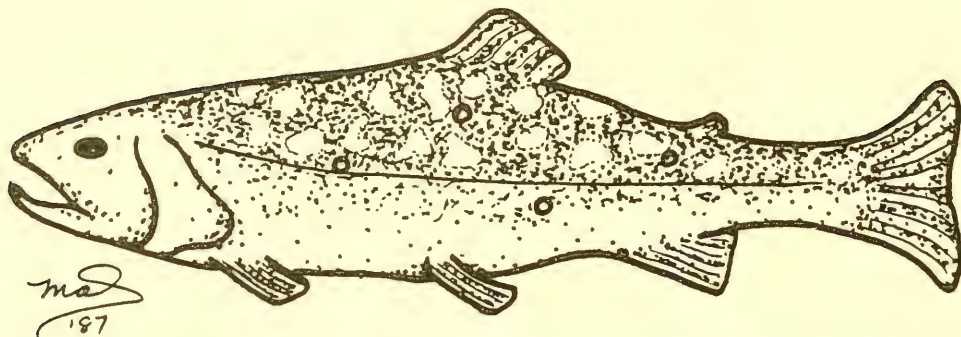


FIGURE 1. Drawing of the Aurora Trout, *Salvelinus fontinalis timagamiensis*, (Courtesy Department of Fisheries and Oceans, drawing by M. Service).

been planted in a number of lakes, but all are dependent on hatchery stock for recruitment.

Systematics of the Aurora Trout remain unclear. The Aurora Trout was originally described as a distinct species *Salvelinus timagamiensis* by Henn and Rinkenbach (1925). Sale (1967) and Qadri (1968) subsequently concluded that it should be recognized as a subspecies of the Brook Trout and therefore *Salvelinus fontinalis timagamiensis*. Recently, McGlade (1980) concluded that the Aurora Trout is not sufficiently distinguished from other populations of Brook Trout to constitute a valid subspecies. P. Ihssen (Ontario Ministry of Natural Resources, Fisheries Research, Maple, Ontario; personal communication) has reviewed this work and concurs with McGlade's designation. Behnke (1980) also examined specimens and reviewed the status of Aurora Trout. He stated that the genetic differentiation between the Aurora Trout and other *Salvelinus fontinalis* was slight but was sufficient to maintain reproductive isolation in sympatry under original conditions. Reproductive isolation would suggest species status. D. McAllister (National Museum of Natural Sciences, Ottawa, Ontario; personal communication) points out that McGlade (1980) did not study or reject the diagnostic character discovered by Qadri (1968) whose study must therefore stand. However, the absence of biochemical differences does imply, of itself, conspecificity. Sale (1967) reported that Aurora and Brook trout were sympatric in Whitepine Lake with little apparent hybridization. The "middle ground" in this taxonomic dispute is to tentatively retain subspecies status.

Protection

Lakes stocked with Aurora Trout are presently (1986) designated as fish sanctuaries. However, recent changes to provincial regulations would

permit limited sports fishing on some lakes while retaining the sanctuary status on specific lakes for perpetuation of the stock. Big Chub Lake (47°06'N, 83°50'W) and Carol Lake (47°34'N, 84°37'W) were opened for the month of August in 1986 with a possession limit of one Aurora Trout.

No other specific protection of the stock or its habitat is provided, although general protection is afforded through the fish habitat sections of the Fisheries Act.

Population Size and Trends

No specific estimates of Aurora Trout population size are available from the original four lakes; however early netting records suggest they were common in those lakes. The OMNR (1984. Unpublished manuscript: Aurora Trout Management Plan and Proposed Work Schedule, January 1984. Ontario Ministry of Natural Resources, Cochrane District, Cochrane, Ontario) reported that Aurora Trout populations in Gamble Township declined rapidly during the 1960s and by 1971 had disappeared completely. Some of the original stock was maintained through the efforts of the OMNR Hill's Lake fish culture station. However, efforts to establish self-sustaining Aurora Trout populations in other lakes have not been successful.

Since 1970, several lakes have been stocked with Aurora Trout to provide a source of spawn for hatchery incubation. In this vein relative success has been achieved. However, recent assessment studies report no significant spawning success in stocked lakes, and it is assumed that these populations will be still dependent on hatchery stocking for some time.

Plans to expand the number of lakes to be stocked have been drafted by the OMNR. These plans suggest that the range of Aurora Trout could



FIGURE 2. Distribution of Aurora Trout, *Salvelinus fontinalis timagamiensis*, in Canada: ● Original Lakes; ○ Stocked Lakes.

expand to nine lakes during the next ten years. The success of stockings and natural recruitment will govern the rate of population expansion.

Habitat

Information on the habitat of Aurora Trout is limited, but habitat preference may be considered very similar to that of other lake populations of Brook Trout.

The original lakes from which Aurora Trout were identified are remote kettle type lakes ranging in surface area from 4 to 25 hectares. Sale (1967) classed these lakes as highly oligotrophic with Secchi disc readings of 5.5 to 9.0 m. Two of the larger lakes were thermally stratified in summer with bottom temperatures of 10°C.

Keller (1978) reported significantly decreased pH levels (5 to 5.5) in these lakes. J. Gunn (Ontario Ministry of Natural Resources, Sudbury, Ontario; personal communication) reports that a program including bioassay tests, water chemistry, and physical measures is on-going on the original Aurora Trout lakes. Preliminary data analysis indicates mean pH levels ranging from 4.5 to 4.8 and elevated heavy metal levels.

During the summer months the Aurora Trout seeks cool water areas and is believed to congregate at or below the thermocline. Little is known of the specific habitat requirements of the Aurora Trout, however areas of sufficient ground water upwelling and suitable substrate for spawning and egg survival are believed critical. These requirements have not been met in the lakes stocked to date.

The rate at which the original habitat of the Aurora Trout has changed during the past 30 years is relatively rapid and can be linked directly to the destructive potentials of lake acidification (Keller 1978).

The OMNR management plan recognizes that the protection and rehabilitation of Aurora Trout may be most efficiently accomplished by stocking Aurora Trout in lakes with suitable water quality and spawning habitat as opposed to rehabilitation of the original Aurora Trout lakes.

General Biology

Reproductive Capability: Aurora Trout spawn in the fall, during late October and early November, at water temperatures of 4 to 6°C. Maturity is reached at 2+ or 3+ years for both sexes. Once mature, adults are believed to spawn every year. Sex ratios of adults are unknown, however spawning adults are easily sexed on the basis of external colouration and sex ratios may be easily obtained.

Growth rates of stocked Aurora Trout are variable between lakes, but may be considered similar to many Brook Trout populations. The approximate maximum size of Aurora Trout recovered from stocked lakes is 60 cm Total Length (TL) and 3.5 kg weight.

Fecundity estimates from adult Aurora Trout 45 to 55 cm TL range from 1300 to 7000 eggs. The wide variance may be attributable to collection methodology. Fecundity estimates were determined from the number of eggs stripped from ripe females as opposed to total counts from excised ovaries.

Species Movement: The lakes in which the Aurora Trout have been stocked are small, usually less than 25 hectares. Aurora Trout may be found dispersed throughout the entire waterbody dependent on season and life stage. Adult Aurora Trout congregate in shallow water near suspected areas of upwelling during the fall and are usually found below the thermocline during the summer months.

Behaviour/Adaptability: An assessment of the degree of tolerance of this stock to human disturbance is difficult because human interference has been of a dramatic nature.

The demise of this stock is, most likely, directly attributable to anthropogenic acidification of its environment (Keller 1978). Survival and rehabilitation has only been possible through the active and intense management of the entire stock. Maintenance of the remaining stock is through

artificial propagation. Successful planting of hatchery fish to develop self-reproducing populations has not been successful to-date.

Limiting Factors

The primary factor suspected of causing the decline of Aurora Trout in their original range is recruitment failure brought on, at least in part, by lake acidification as a result of acid precipitation.

The success of rehabilitation plans will depend on the ability to develop self reproducing populations and on the protection afforded to those populations.

Special Significance of the Species

The OMNR (1984) has described the Aurora Trout as a stock of Brook Trout of unique characteristics that has scientific value and recreational interest. Aurora Trout have received considerable attention from the recreational community in the past primarily as a result of their unique colouration.

The Aurora Trout is an example of, at the least, a discrete fish stock and may even be a valid subspecies. The importance of preserving and managing such stocks has been identified by the scientific community (STOCS 1981). The Aurora Trout is also of special interest because their demise has been so strongly linked to the impacts of acidic precipitation.

Evaluation

The following factors were used in the evaluation of the status of the Aurora Trout in Canada:

1. Stock endemic to four lakes in northeastern Ontario.
2. Probably extirpated from its entire range and now only maintained by artificial propagation. Reintroduction of self-reproducing populations has not been successful to date.
3. Artificial propagation and maintenance of the stock gene pool is carefully monitored by the OMNR. Several thousands of fish including immature and mature individuals are maintained in sanctuary lakes and hatchery facilities.
4. Reproductive and population failure of stock in original lakes linked to anthropogenic lake acidification.
5. Recognized as an isolated unique stock or a subspecies and may, therefore, be considered a species under the approved definitions of COSEWIC.

Based on the information evaluated, it is recommended that the Aurora Trout should be classed as endangered.

Acknowledgments

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Status of the Shortnose Cisco, *Coregonus reighardi*, in Canada*

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Parker, B. J. 1988. Status of the Shortnose Cisco, *Coregonus reighardi*, in Canada. *Canadian Field-Naturalist* 102(1): 92-96.

Coregonus reighardi occurred historically in lakes Ontario, Huron and Michigan. In Canada, the species has been reported as extirpated from Lake Ontario, and present, but of unknown status, in Lake Huron. The Shortnose Cisco is not specifically protected in Canada, although general protection is afforded through the fish habitat sections of the Fisheries Act.

L'espèce *Coregonus reighardi* se rencontrait jadis dans les lacs Ontario, Huron et Michigan. Au Canada, on a indiqué que cette espèce était déracinée dans le lac Ontario, et qu'elle était présente, mais sans qu'on en connaisse la situation, dans le lac Huron. Le Cisco à museau court n'a pas d'une protection particulière au Canada, bien qu'une protection générale lui soit accordée par le biais des articles de la Loi sur les pêcheries portant sur l'habitat du poisson.

Key Words: Shortnose Cisco, *Coregonus reighardi*, coregonids, rare and endangered species, chub, herring.

The Shortnose Cisco, *Coregonus reighardi*, is one of the smaller deepwater ciscos indigenous to the Great Lakes. The fish (Figure 1) grow to a length of approximately 30 cm and may achieve weights of up to 540 g. These fish have a short snout(hence the name) and a small mouth. The lower jaw does not protrude beyond the upper jaw. The scales are large and the fish are yellow green dorsally with prominent silvery sides and a white ventral surface (see Scott and Crossman 1973 for detailed description). Shortnose Ciscos were important in the commercial chub fishery of the Great Lakes prior to 1940. They are now thought to be extirpated from lakes Ontario and Michigan although the species is still extant in Georgian Bay and Lake Huron.

Distribution

Coregonus reighardi is indigenous to the Great Lakes basin, with a historic range encompassing lakes Huron, Michigan and Ontario (Koelz 1929; Pritchard 1931; Smith 1964). Reports of this species in Lake Superior and Lake Nipigon were based on misidentifications with *Coregonus zenithicus* (T. Todd, Great Lakes Fisheries Laboratory, Ann Arbor, Michigan; personal communication). It is now considered extirpated from lakes Ontario and Michigan (Crossman and Van Meter 1980; Todd 1980). Todd (personal communication) suggested that only a few *Coregonus reighardi* are captured each year in the U.S. waters

of Lake Huron, but that it remains common in Georgian Bay (Figure 2). These reports would, therefore, suggest that the *Coregonus reighardi* specimens found in Georgian Bay constitute the final and only population center remaining for this species.

The difficulties in taxonomic placement of this species has created a legacy of misidentifications, especially in Lake Superior and Lake Nipigon. Historically, Koelz (1929) recognized two subspecies, *Coregonus reighardi dymondi* in lakes Superior and Nipigon, and *Coregonus reighardi reighardi* in lakes Ontario and Michigan. However, Todd and Smith (1980) reviewed the systematics of this species and concluded that specimens taken from Lake Superior and Lake Nipigon are not subspecific to *Coregonus reighardi* but are a variant of *Coregonus zenithicus*. Todd (1980) indicated that the form in Lake Huron, Lake Michigan and Lake Ontario was *Coregonus reighardi*.

Protection

No specific legal protection exists for the Shortnose Cisco in Canada. *Coregonus reighardi* is currently under consideration by the United States Fish and Wildlife Service as an endangered species (J. Engel, U.S. Fish and Wildlife Service, Endangered Species Division, Minneapolis, Minnesota; personal communication). This species is also designated as endangered by the State of Michigan (Endangered Species List,

*Threatened status assigned by COSEWIC 7 April 1987.

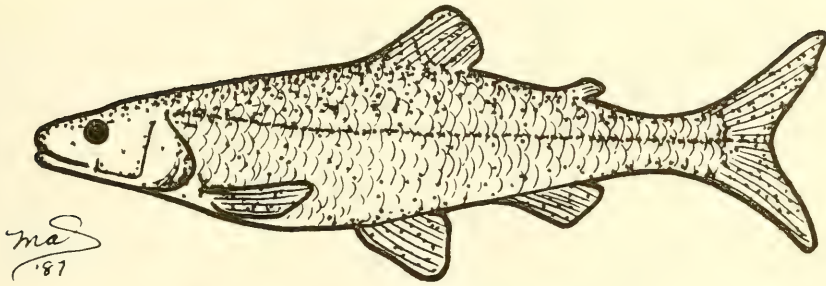


FIGURE 1. Shortnose Cisco, *Coregonus reighardi*. (Drawing by M. Service, Department of Fisheries and Oceans).

February 1983 — pursuant to Public Act 203), and is legally protected from collection. In the states of Illinois, Indiana, Wisconsin, Minnesota, and New York, *Coregonus reighardi* is considered to be extirpated. This species is not legally protected in these jurisdictions.

Commercial harvest quotas or effort restrictions for deepwater cisco as a group are in effect in Illinois (R. Hess, Illinois Department of Conservation, Zion, Illinois, personal communication), the Lake Michigan waters of Wisconsin (L. Kernan, Wisconsin Department of Natural Resources, Madison, Wisconsin, personal communication), Minnesota (J. Spurrier, Minnesota Department of Natural Resources, St. Paul, Minnesota, personal communication) and the Lake Superior waters of Michigan (J. Peck, Michigan Department of Natural Resources, Lansing, Michigan, personal communication). The deepwater cisco fishery in Michigan waters of Lake Huron is closed, and is also closed in much of the Michigan waters of Lake Michigan (A. Wright, Michigan Department of Natural Resources, Lansing, Michigan, personal communication). Recently (1984), commercial harvest quotas for deepwater cisco were instituted for Ontario waters of the Great Lakes (R. Payne, Ontario Ministry of Natural Resources, Owen Sound, Ontario, personal communication).

Population Size and Trend

The Shortnose Cisco was an important commercial species in Lake Ontario (Crossman and Van Meter 1980). Pritchard (1931) reports that *Coregonus reighardi* was the main cisco species taken off Toronto in the 1880s. In 1927, *Coregonus reighardi* constituted only 3.4% of the total catch

of lesser coregonids in experimental gill-net samples off Port Credit, Ontario (Pritchard 1931). The commercial harvest of this species had collapsed by the late 1930s (Gray 1979). Stone (1944) reports that in experimental fishing in New York waters during 1942, only four specimens were collected, constituting 0.17% of the total cisco catch. The last known record from Lake Ontario was in 1964 off Rochester, New York (Wells 1969). The Lake Ontario population is now considered extirpated (Todd 1980).

Index netting conducted in Lake Michigan documented the depletion of *Coregonus reighardi* stocks from 1930 to 1961 (Smith 1964). The last known record from Lake Michigan was in 1972, and this species is now considered extirpated from this lake (Todd 1980).

Specific information regarding population sizes and trends for *Coregonus reighardi* in Lake Huron is limited. Todd (1980) reported this species as previously common in the deep waters of Lake Huron, yet few specimens have been collected. The first record for *Coregonus reighardi* in Lake Huron was in 1956 (Scott and Smith 1962). A single Shortnose Cisco specimen [National Museums of Canada (NMC) 60-493A] was taken in Lake Huron (44°29'N, 81°53'W) in 1960. Todd (personal communication) stated that a few specimens are caught in the Michigan waters of Lake Huron each year. Although *Coregonus reighardi* constituted between 1-2% of the commercial catch in Ontario waters of the lake in 1975, it is now considered even less abundant (Payne, personal communication). Highly size-selective fisheries in Lake Huron are known to have heavily exploited the smaller-sized cisco species, including Shortnose Cisco (Berst and Spangler 1972).



FIGURE 2. Distribution of the Shortnose Cisco in Canada.

Extant, Georgian Bay (rare to common).

1. Extirpated (Todd 1980).

2. Rare, Lake Huron (T. Todd, personal communication).

Habitat

Little is known of the degree of habitat specialization of this species. Depth distribution is generally shallower than most other deepwater ciscos, and other than maintaining a close association with the bottom during spawning, *Coregonus reighardi* apparently inhabits the midwaters during the balance of the year (Stone 1944; Gray 1979). Scott and Crossman (1973) have summarized the depth distribution of *Coregonus reighardi* in the Great Lakes. In Lake Ontario, this species was reported from depths of 23 to 91 m, with maximum abundance at 77 m. In Lake Michigan *Coregonus reighardi* were captured from 11 to 165 m. No depth of capture information is available for Lake Huron.

Trends in habitat quality specific to the species are unknown as is the rate of habitat change. No specific protection for the habitat of this species exists in Canada or the United States.

General Biology

Reproductive Capability: Breeding age, breeding frequency, fecundity, early life history, age/sex ratio, and structure of populations of this species are unknown. Females outlive males by about two years in Lake Michigan, where females attain an

age of 8+ years (Jobes 1943). Growth is slow; Scott and Crossman (1973) have summarized available age/length/weight data for Lake Ontario and Lake Michigan populations. Adults range in length from 170-260 mm Standard Length (Todd 1980).

Spawning in Lake Ontario occurred in April and May (Pritchard 1931); in May and June in Lake Michigan (Jobes 1943). *Coregonus reighardi* is known to aggregate for spawning (Pritchard 1931; Stone 1944; Smith 1964). This is the only deepwater cisco which spawns in the spring.

Fecundity and frequency of reproduction are unknown, as is the growth potential.

Species Movement: Shortnose Cisco are reported to concentrate near the bottom for the spawning period, but apparently disperse to mid-water zones during the balance of the year (Stone 1944; Smith 1964). Breeding and wintering ranges have not been documented.

Behaviour/Adaptability: An assessment of the degree of tolerance of this species to human disturbance is difficult because human interference, where documented, has been of a dramatic nature. The intense exploitation of *Coregonus reighardi* by the commercial fisheries evidently led

to the extirpation or drastic reduction of populations (Smith 1964; Berst and Spangler 1972; Christie 1972).

The degree of food specialization is unknown. Food items of Lake Ontario specimens of *Coregonus reighardi* included mostly *Mysis relicta* and *Pontoporeia hoyi*, and small quantities of copepods, aquatic insect larvae and small clams (Scott and Crossman 1973).

Information is too limited to establish the degree of specialization of this species in relation to habitat and breeding sites. Spawning in Lake Michigan was reported to occur at depths of 27 to 145 m, with substrates consisting of sand, silt, and clay, and water temperatures ranging between 3.8° and 4.7° C (Jobes 1943). Spawning in western Lake Ontario occurred at 75 m (Pritchard 1931).

Limiting Factors

Over-exploitation by the commercial fisheries was primarily responsible for the collapse and/or extirpation of *Coregonus reighardi* populations in lakes Michigan, Huron and Ontario (Smith 1964; Berst and Spangler 1972; Christie 1972). Sea Lamprey (*Petromyzon marinus*) predation may have also contributed to the decimation of populations in lakes Michigan, Ontario and Huron (Lawrie and Rahrer 1972). In Lake Ontario, competition for food with Rainbow Smelt (*Osmerus mordax*) may also have been a factor in the collapse of deepwater cisco stocks (Christie 1972).

Competition for food with Alewife (*Alosa pseudoharengus*) and Rainbow Smelt may be a factor in the failure of deepwater cisco populations to become re-established in Lake Huron (Berst and Spangler 1972).

Colby et al. (1972) also suggest that eutrophication may be a factor limiting the re-establishment of deepwater cisco in Lake Ontario, possibly by interfering with reproduction.

Special Significance of the Species

Coregonus reighardi was commercially important in the past, and as part of the deepwater cisco community this species would have been part of the traditional forage base for Lake Trout (*Salvelinus namaycush*) and Burbot (*Lota lota*).

Evaluation

The following factors were used in the evaluation of the status of the Shortnose Cisco in Canada:

1. Species endemic to Great Lakes.

2. Seven species of deepwater cisco are recognized, five of the seven have greatly reduced ranges and populations.
3. Historic range greatly reduced and population levels in remaining population centers much reduced, possibly declining.
4. Population structure and ecology of remaining stocks not known.
5. Demise of species in other parts of range, related at least in part, to exploitation by commercial fishery.

Based on the information evaluated, it is recommended that the Shortnose Cisco be classified as Threatened in Canada. It is imperative that population and life history studies for this species be initiated.

Acknowledgments

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Status of the Shortjaw Cisco, *Coregonus zenithicus*, in Canada*

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Houston, J. J. 1988. Status of the Shortjaw Cisco, *Coregonus zenithicus*, in Canada. *Canadian Field-Naturalist* 102(1): 97-102.

The Shortjaw Cisco (*Coregonus zenithicus*) was formerly abundant in the deeper areas of lakes Michigan and Huron. The last, valid, known, occurrences in lakes Michigan and Huron were in 1975 and 1982, respectively. The species is now considered to be extirpated from these lakes. However, these fish are known to have extant populations in lakes Superior and Nipigon and in some lakes in central Canada. Shortjaw Cisco inhabit deep waters, well below the thermocline, preferring depths of 55-144 m. Spawning occurs in shallower waters, about half of the normal depth in which the fish are found in the fall or spring depending on the population. The reasons for the restricted distribution of *Coregonus zenithicus* are most likely overfishing by the intensive chub fishery, Sea Lamprey (*Petromyzon marinus*) predation that accompanied the disappearance of the Lake Trout (*Salvelinus namaycush*) in the upper Great Lakes, and competition or predation from introduced Alewife (*Alosa pseudoharengus*) and Rainbow Smelt (*Osmerus mordax*). These factors, in stressing the cisco populations of the Great Lakes, may have also led to introgressive hybridization of these coregonid fishes. Current theories suggest some doubt as to whether the subspecies *Coregonus nigripinnis cyanopterus* and *Coregonus reighardi dymondi* are taxonomically distinct from *Coregonus zenithicus* with which they are now regarded as conspecific.

Le Cisco à mâchoires égales (*Coregonus zenithicus*) était autrefois abondant dans les eaux profondes des lacs Michigan et Huron. C'est en 1975 et 1982 que sa présence a été décelée pour la dernière fois de façon certaine dans, respectivement, les lacs Michigan et Huron. On pense que l'espèce est maintenant disparue de ces lacs. On en rencontre cependant des populations importantes dans les lacs Supérieur et Nipigon. Le Cisco à mâchoires égales habite les eaux profondes, bien en-deçà de la thermocline, préférant les profondeurs de 55 à 144 m. Il fraie dans des eaux moins profondes, environ à la moitié des profondeurs qu'il fréquente normalement, à l'automne ou au printemps, selon la population. L'aire de répartition restreinte de *Coregonus zenithicus* est fort probablement due à la surpêche liée à la pêche intensive des corégones et à la prédation par la Lamproie marine (*Petromyzon marinus*) qui a marqué la disparition du Touladi (*Salvelinus namaycush*) dans les Grands lacs d'amont, de même qu'à la compétition ou à la prédation par les Gaspareaux (*Alosa pseudoharengus*) et Éperlans (*Osmerus mordax*) introduits. Ces facteurs, sources de contraintes pour les populations de cisco des Grands lacs, ont pu aussi être la cause d'une hybridation introgressive de ces corégonidés. On met actuellement en doute le bien-fondé de la taxonomie des sous-espèces *Coregonus nigripinnis cyanopterus* et de *Coregonus reighardi dymondi*, qui sont actuellement considérées comme conspécifiques à *Coregonus zenithicus*.

Key Words: Shortjaw Cisco, *Coregonus zenithicus*, chub, herring, rare and endangered species.

The Shortjaw Cisco (*Coregonus zenithicus*) is a freshwater coregonid of the Great Lakes and various other large water bodies of central North America. These fish (Figure 1) have an elliptically shaped body which is compressed laterally and covered with large, smooth scales. They are olive green dorsally with obvious silvery sides and are white below. This cisco has a small mouth with no teeth and the jaws are usually of equal length. It grows to over 30 cm in length and weighs approximately 300 g. Females tend to be heavier than males and also live longer, thereby reaching greater size. They migrate seasonally between depths of 110 to 144 m in spring, 55 to 71 m in summer, and 73 to 90 m during winter.

Distribution

Shortjaw Cisco (*Coregonus zenithicus*) were formerly distributed in lakes Huron, Michigan, Superior and Nipigon (Scott and Crossman 1973) in the Great Lakes Basin (Figure 2). The last, verified, known occurrences of this species in lakes Michigan and Huron were in 1975 and 1982 respectively (Ono et al. 1983; Todd 1985). However, both reports probably represent strays from Lake Superior (Ono et al. 1983) where there is an extant population.

Fish described as this species, have also been reported from Lake Winnipeg, Manitoba; Reindeer Lake, Lake Athabasca, Saskatchewan; Barrow Lake, Alberta (Paterson 1969; Clarke

*Threatened status approved and assigned by COSEWIC 7 April 1987.

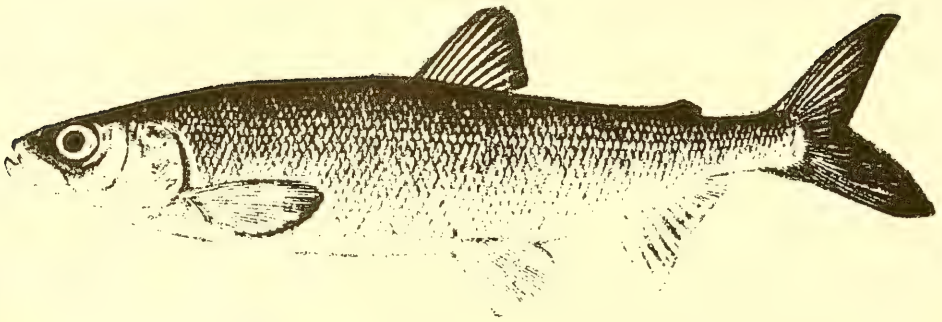


FIGURE 1. Shortjaw Cisco (*Coregonus zenithicus*).

1973), and Great Slave Lake, Northwest Territories [NWT] (Scott and Crossman 1973). The occurrences of *Coregonus zenithicus* in waters other than the Great Lakes basin have often been viewed with scepticism, although they fit most of the classical criteria necessary for the taxonomy of this species (Scott and Crossman 1973). Clarke's (1973) investigation of systematics of ciscos in central Canada concluded *Coregonus zenithicus* is a valid species occurring in some lakes of central Canada. Further investigation into the morphological and meristic characteristics of the subgenus *Leucichthys* in Canadian lakes is needed before their complete range outside the Great Lakes basin is fully known.

Protection

There is no specific protection for the Shortjaw Cisco in Canada, except the general protection afforded through the Fisheries Act.

Population Size and Trends

Coregonus zenithicus, along with other larger ciscos in the subgenus *Leucichthys*, known commercially as chubs, supported the Great Lakes fishery since the mid 19th century. Commercial harvest levels of the early Great Lakes fishery are not well documented. The earliest reliable records are from the Lake Michigan fishery between 1926–1939.

Little is known of the former abundance of the species in Lake Huron and no records of the fishery are available. The last known specimen from Lake Huron was recorded in 1982 (Ono et al. 1983; Todd 1985). The situation in Lake Huron probably closely resembled that in Lake Michigan (T. N. Todd, Fisheries Biologist, U.S. Fish and Wildlife Service, Great Lake Fisheries Laboratory, Ann

Arbor, Michigan, personal communication) and a discussion of the Lake Michigan fishery provides some insight for Lake Huron.

The abundance of the various cisco species prior to the 1900s was probably uniform in Lake Michigan (Smith 1964). However, after this an intensive and selective fishery disrupted these virgin stocks. The larger deepwater species *Coregonus nigripinnis* (Blackfin Cisco), *Coregonus johannae* (Deepwater Cisco), and *Coregonus alpenae* (Longjaw Cisco) primarily supported the earliest chub fishery (Hile and Buettner 1955). As the gill net fishery intensified, the number of these larger ciscos declined and accordingly, the mesh sizes were decreased to try to maintain the existing catch levels. By the 1930s, *Coregonus nigripinnis* and *Coregonus johannae* represented only a small segment of the Lake Michigan chub fishery (Smith 1964) and *Coregonus zenithicus* and other intermediate size chubs (*Coregonus artedii*, *Coregonus reighardi*) became important contributors to the fishery. Their abundance in Lake Michigan, represented two-thirds of the cisco stock of the deepwater zone in the 1930s, but declined to 24% and 6.4% in the 1950s and 1960s respectively (Smith 1964). During these years of intensive fishing and predation by the Sea Lamprey (*Petromyzon marinus*), the Bloater (*Coregonus hoyi*), a small, slow-growing cisco was favoured and its abundance increased accordingly. The increased competition from the Bloater, competition or predation by exotic species such as Rainbow Smelt (*Osmerus mordax*) and Alewife (*Alosa pseudoharengus*) and Sea Lamprey undoubtedly added to the forces of the fishery in reducing the numbers of larger ciscoes (Smith 1964). By the 1960s the trawl fishery had become established. *Coregonus hoyi* dominated all the

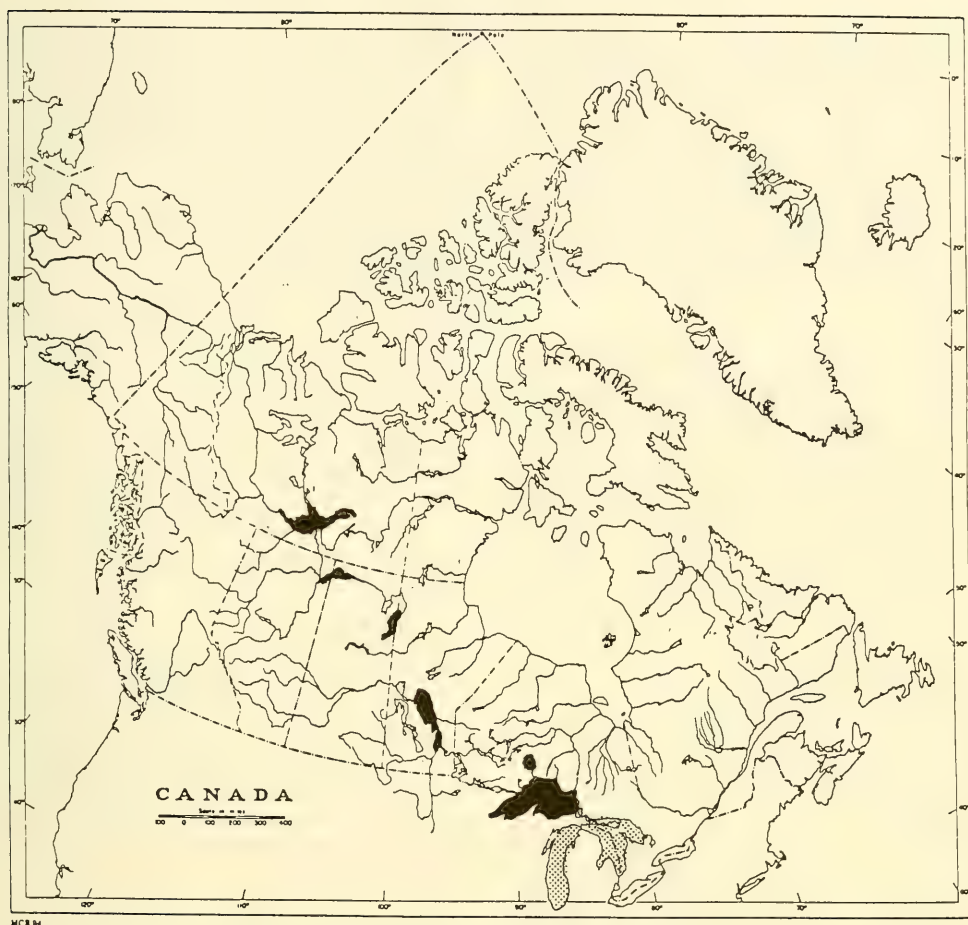


FIGURE 2. Canadian distribution of the Shortjaw Cisco.

Former distribution: stippled.

Present distribution: solid.

trawl catches and *Coregonus nigripinnis* and *Coregonus johanna* appeared to be extinct in Lake Michigan (Smith 1964). The bloater now dominates all areas of lakes Michigan, Superior and Huron, where the larger ciscoes once had healthy stocks (Todd 1985).

Koelz (1929) reported that *Coregonus zenithicus* was the most common species in Lake Superior (up to 90%) in the 1920s. It now represents less than 5% of catches (Peck 1977).

Shortjaw Cisco, it would appear, were abundant throughout their range until the early 1930s. At this time these fish were probably at their highest numbers with little competition and predation

from larger fish. The intensive and selective fishery required to maintain catch levels subsequently seriously decreased their numbers by the mid 1950s. *Coregonus zenithicus* bowed to the pressure of the fishery, competition, and predation from exotic species. It is also possible that introgressive hybridization completed their demise in lakes Michigan and Huron. At present the Shortjaw Cisco should be considered to be threatened with extinction, at least in Lake Superior (T. Todd, personal communication) and common in Lake Nipigon, especially in McIntyre Bay where they occur sympatrically with *Coregonus clupeaformis*, the Lake Whitefish, and *Catostomus commersoni*,

the White Sucker (R. Borecky, Biologist, Lake Nipigon Fisheries Assessment Unit, Ontario Ministry of Natural Resources, Nipigon, Ontario; N.R. Payne, Supervisor, Lake Huron Fisheries Assessment Unit, Ontario Ministry of Natural Resources, Owen Sound, Ontario; personal communications).

Although the species has been mentioned as occurring in Manitoba, Saskatchewan and the NWT (see Clarke 1973) the distribution and abundance in these areas is uncertain and their present status is unknown.

Habitat

The Shortjaw Cisco usually inhabits waters of 55 to 144 m in depth, although they have been taken at depths up to 183 m and as little as 18 m in the Great Lakes (Scott and Crossman 1973). Their seasonal movement in Lake Superior was observed by Dryer (1966) who indicated their depth distribution to be 110–144 m in spring, 55–71 m in summer and 73–90 m in winter. At spawning time these fish move to shallower waters, approximately half the depth they usually inhabit.

General Biology

The Shortjaw Cisco was originally thought to be a fall spawner in lakes Michigan, Huron, Superior and Nipigon. However, numerous observations of these fish spawning in May–June have been made during the last 25 years in Lake Superior (Todd and Smith 1980). When spawning does occur, eggs are deposited on the bottom (usually clay) and abandoned, with development occurring over the few subsequent months. The early life history, fecundity and embryological development are not well known (Scott and Crossman 1973). Fecundity studies on ciscos in the Great Lakes have indicated that the number of eggs correlates positively with the size of the female. Although no specific numbers are given for the Shortjaw Cisco, an average 30 cm female cisco may be capable of producing upwards of 20 000 eggs.

Growth of the Shortjaw Cisco is fairly rapid within its first year with a tendency to slow down over subsequent years. In addition, weight increase is not pronounced until after the first four years of growth, where an increase of 53% (male) and 66% (female) has been reported to occur during their fifth or sixth year (Scott and Crossman 1973). Males and females grow at about the same rate; but due to the greater longevity of the female they can attain a greater size than that of the male. In Lake Superior, Shortjaw Cisco attain an average length of 23 cm and a weight of 77 g by their fourth year

(Scott and Crossman 1973). Older individuals have measured 35.1 cm in length with weights of 276 g for males and 36.8 cm in length, and weights of 292 g for females (Scott and Crossman 1973). Recent deepwater trawls in McIntyre Bay, Lake Nipigon, have found *Coregonus zenithicus* to be 0.5 kg to 1 kg in weight and up to 40 cm in length (R. Borecky, personal communication). Sexual maturity is usually reached by the fifth or sixth year for ciscos of the Great Lakes.

Freshwater shrimp *Pontoporeia* and *Mysis relicta* are the primary food items of the adult Shortjaw Cisco (Bersamin 1958). Planktonic crustaceans, insect larvae and some aquatic vegetation are also known to be utilized (Koelz 1929; Ono et al. 1983). In turn, the Shortjaw Cisco forms a part of the natural diet for Lake Trout (*Salvelinus namaycush*) and Burbot (*Lota lota*). Following the introduction of the Sea Lamprey, the Shortjaw Cisco was probably preyed upon by them as well, especially after the Sea Lamprey had decimated its natural prey, the Lake Trout and Burbot (Scott and Crossman 1973).

Limiting Factors

There are insufficient data to unequivocally identify any specific limiting factor which may have led to the demise of the Shortjaw Cisco in lakes Michigan and Huron. Initially, the abundance of these fish may have been limited by predation only, as they are part of the natural diet of Lake Trout and Burbot. In addition, competition from other ciscos may have restricted their numbers. The over-exploitation of the larger species (*Coregonus alpenae*, *Coregonus johannae*, and *Coregonus nigripinnis*) during the first part of the 20th century, compounded with their reduction in numbers by Sea Lamprey in the mid-1900s may have led to a temporary increase in the abundance of the Shortjaw Cisco. With the later reduction in mesh sizes to try and maintain catch levels, *Coregonus zenithicus* numbers soon began to decline and fewer fish were able to reach reproductive age. By the 1950s intensive fishing pressure in order to maintain quotas along with the introduction of deepwater trawls probably left the stocks of the Shortjaw Cisco beyond natural rehabilitation in lakes Michigan and Huron.

Competition for food with Alewife and Rainbow Smelt may be a factor in the failure of Deepwater Cisco populations to become re-established in Lake Huron (Berst and Spangler 1972).

Habitat loss, environmental contamination or other aspects of human disturbance are possible

factors which may have led to shifts in abundance of related species. *Coregonus hoyi*, the smallest cisco became increasingly abundant throughout the Great Lakes at this time and now has become the supporting cisco of the chub fishery. The effects of increased abundance of the Bloater, may have created a situation optimal for introgressive hybridization to occur. Some researchers feel that introgressive hybridization has been taking place and that rare species have hybridized with more common related species such as *Coregonus hoyi* and *Coregonus artedii* (Smith 1964; Scott and Crossman 1973). This is not well documented and at present is still theoretical but remains a distinct possibility (T. Todd, personal communication). This phenomenon is also thought (Regier et al. 1969) to have been involved in the disappearance of other taxa such as the Blue Walleye (*Stizostedion vitreum glaucum*).

Special Significance of the Species

The Shortjaw Cisco is now presumably extirpated or so rare as to be beyond rehabilitation in lakes Michigan and Huron (Todd 1985). Lakes Superior and Nipigon and some lakes in central Canada appear to have extant populations of *Coregonus zenithicus* (Clarke 1973; Lee et al. 1980). This species once played an integral part in the Great Lakes "chub" fishery in lakes Huron and Michigan. Smoked Shortjaw Cisco were considered a delicacy in the almost exclusive United States market (Scott and Crossman 1973).

Evaluation

Since the last known validated occurrences of *Coregonus zenithicus* in lakes Michigan and Huron were in 1975 and 1982 respectively, this species is now considered to be extirpated from these lakes. In Lake Superior, *Coregonus zenithicus* populations have undergone a drastic decline over this century. At one time, it was considered common, but the species now represents less than 5% of the Lake Superior catch and its continued presence there is now threatened. In Lake Nipigon, the Shortjaw Cisco is still considered to be common. The occurrence of *Coregonus zenithicus* in some lakes in central Canada has been verified, but the distribution and abundance for these lakes is unknown. The continued presence of the species in Canadian waters is threatened by habitat degradation, competition with exotic species and commercial exploitation.

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Status of the Lake Simcoe Whitefish, *Coregonus clupeaformis*, in Canada*

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The Lake Simcoe Whitefish (*Coregonus clupeaformis*) stock is spatially isolated and separated from adjacent Great Lakes whitefish stocks by geographic and man-made barriers, and has been reported to be genetically distinct from adjacent allopatric stocks. The population was estimated to number 250 000 in 1979, a decline of 85% since 1963 to 1965. Recruitment has been very low since 1970 even though spawning occurs and larvae are present in the surface waters during early spring (May). The spawning substrate utilized by the Lake Simcoe Whitefish consists of cobble-boulder limestone over a sand, clay or bedrock base extending from the shoreline to a depth of several metres. Deterioration of habitat quality has occurred, but the effect on reproductive success is unknown. Ecological stresses, including eutrophication, and the introduction of Rainbow Smelt (*Osmerus mordax*), appear to be the primary factors limiting the success of the population. Whitefish is the major species of interest to winter anglers in Lake Simcoe and the fishery generates considerable revenue for local business. The continued existence of the Lake Simcoe Whitefish is threatened by environmental stresses, and because of low population numbers, is in danger of extinction. The Ontario Ministry of Natural Resources initiated a stocking program in 1982, with the aim of maintaining the native stock until such time that natural reproduction can be restored.

Les Grands corégones (*Coregonus clupeaformis*) du lac Simcoe constituent un stock spatialement isolé que des barrières géographiques ou artificielles séparent des stocks de corégones adjacents des Grands Lacs. On a signalé que ce stock différait génétiquement des autres stocks allopatriques avoisinants. Sa population a été estimée à 250 000 en 1979, ce qui représente un déclin de 85% par rapport à la période 1963 à 1965. En dépit du fait qu'il y ait frai et que des larves soient présentes dans les eaux de surface au début du printemps (mai), le recrutement a été très faible depuis 1970. Le Grand corégone du lac Simcoe fraie de préférence dans des zones à fond de gailllette-pierre roulé calcaire par-dessus une base de sable, d'argile ou d'un fond rocheux s'étendant du rivage jusqu'à une profondeur d'environ quelques mètres. Il y a eu détérioration de la qualité de l'habitat, mais nous n'en connaissons pas les effets sur le succès de la reproduction. L'eutrophisation et l'introduction de l'éperlan arc-en-ciel (*Osmerus mordax*) comptent parmi les contraintes écologiques qui semblent être les principaux facteurs limitant cette population. Le Grand corégone constitue la principale espèce recherchée en hiver par les pêcheurs sportifs du lac Simcoe et cette pêche est source de revenus importants pour les commerçants de la région. L'existence du Grand corégone du lac Simcoe est menacée par des contraintes environnementales et ses faibles effectifs l'exposent à la disparition. Le ministère des Richesses naturelles de l'Ontario a mis sur pied un programme de repeuplement en 1982 dans le but de maintenir les effectifs du stock indigène jusqu'à ce que la reproduction naturelle puisse être rétablie.

Key Words: Lake Simcoe Whitefish, *Coregonus clupeaformis*, population size and trends, recruitment failure, threatened, distribution.

The Lake Simcoe Whitefish is a genetically discrete stock of the Lake Whitefish, *Coregonus clupeaformis* (Ihssen et al. 1981), having been separated from nearby stocks in the Great Lakes region for about 7000 to 10 000 years by geographic and man-made barriers. The Lake Simcoe Whitefish has been exploited by commercial and recreational fisheries for well over 100 years (MacCrimmon and Skobe 1970). Catch records prior to 1960 are incomplete, but the harvest was in excess of 50 000 kg per year as

recently as 1960 to 1970 (Evans and Waring 1987). Angling has been the primary means of exploitation since about 1900 when gillnetting and spearing became illegal. The fishery is now entirely recreational, occurring primarily from January to March when the lake is ice covered. Since 1970, catches have declined due to recruitment failure, which began during the late 1960s.

The Lake Simcoe Whitefish was formerly known as a small whitefish, adults averaging about 0.5 kg (Rawson 1930). At presently reduced

*Threatened status approved and assigned by COSEWIC 7 April 1987.



FIGURE 1. Photograph of a female Lake Simcoe Whitefish, *Coregonus clupeaformis*, caught off the north shore of Georgina Island, Lake Simcoe, 11 November 1981: age = 8+ years (opercular bone); Weight = 1297 g; FL = 472 mm; TL = 531 mm; Body Depth = 114 mm; Left ovary = 81.2 g; Right ovary = 135.3 g.

population densities, however, average body weight exceeds 1 kg (Evans 1978a). Body shape is elongate, with a notable post-cranial hump in large, older individuals (Figure 1). Colouration is very pale green on the dorsal surface, silvery on the flanks and silvery-white on the ventral surfaces. During the spawning periods, the dorsal and caudal fins are dusky, while the pectoral, pelvic and anal fins are very pale yellow-orange with dusky coloured extremities. At other times, the paired fins and anal fin tend to be less coloured. Detailed morphometric and meristic information has been reported by Ihssen et al. (1981).

Distribution

The Lake Whitefish is found in North American freshwaters from Atlantic coastal watersheds, westward across Canada and the United States (Figure 2), to British Columbia, the Yukon Territory and Alaska (Scott and Crossman 1973). The Lake Simcoe Whitefish population is a unique stock occurring in Lake Simcoe, Ontario. This stock has recently been transplanted to Upper Roslyn Lake (49° 15' N, 87° 29' W), a 1034 ha lake located northeast of Nipigon, Ontario. The status of the stock in Upper Roslyn Lake is unknown.

Lake Simcoe (44° 25' N, 79° 20' W) is located in southern Ontario, between Georgian Bay and Lake Ontario, and is the seventh largest inland lake in the Province of Ontario. The surface area of the lake is 725 km² with a mean depth of 17 m and a maximum depth of 41.5 m occurring near the center of Kempenfelt Bay (Figure 3). Lake Simcoe, being part of the Trent Canal system, provides a navigational link between eastern Lake Ontario and Georgian Bay of Lake Huron. The canal system incorporates a marine railway at Big Shute

on the Severn River, and a series of locks which prohibit immigration of whitefish from lakes Ontario and Huron. Therefore, the whitefish of Lake Simcoe is spatially isolated from other populations of Lake Whitefish in Lake Huron and Lake Ontario by impenetrable geographic barriers.

Protection

The Lake Simcoe Whitefish is protected under the Federal Fisheries Act of 1867, and the 1976 Amendment to the Act, requiring protection and management of all commercial fish species and their habitat. In addition, the present Ontario Fisheries Regulations specify a possession limit of two Lake Simcoe Whitefish per person, and an angling season extending from 1 January to 15 March, and from the second Saturday in May, until 15 October. These regulations were established in 1977. Prior to this, no possession limit or seasonal regulations for angling existed for this species in Lake Simcoe. Regulations were introduced in order to protect the declining whitefish population, although fishing was not the cause of the recruitment failure.

Population Size and Trends

In a mark-recapture study in 1976 to 1979, the adult whitefish population in Lake Simcoe was estimated to be 250 000 fish, a decline of 40% since 1972, and a decline of 83% (Table 1) since 1963 to 1965 (DesJardine and Lawrence 1977). Catch statistics from winter creel surveys from 1963 to 1979 also indicate that the whitefish population has undergone a steady decline. Catch per unit effort (CPUE) in the winter angling fishery decreased from 0.377 fish/hr in 1965 (Holder and



FIGURE 2. Distribution of Lake Whitefish, *Coregonus clupeaformis*, in North America (adapted from Scott and Crossman 1973).

Townes 1965) to a low of 0.008 fish/hr in 1977, reflecting a decline in the estimated catch from 153 000 to 3 000 fish (DesJardine and Lawrence 1979). Subsequently, catches have increased to their present level of 14 000-15 000 per year (1981 to 1983), and a CPUE of 0.031 whitefish per angler hour (Wilcox 1985; Evans and Waring 1987).

The decline in whitefish population size has been coincident with an increase in mean body size. Historically, Lake Simcoe Whitefish were noted for their small size. Rawson (1930) reported a mean weight 0.51 kg for several thousand whitefish

captured during 1925 to 1928. Semple (1968) reported a mean weight of 0.58 kg for a sample of 400 spawning whitefish caught during 1966 and 1967 compared to 1.27 to 1.47 kg from 1977 to 1983 (Evans 1978a; Wilcox 1985). Growth rates have increased, presumably due to decreased intraspecific competition. Very few young fish have been recruited into the population since the early 1970s, and the age structure has gradually shifted towards older, larger individuals. The change in mean body size is due to increased growth and a shift in the age structure of the stock.

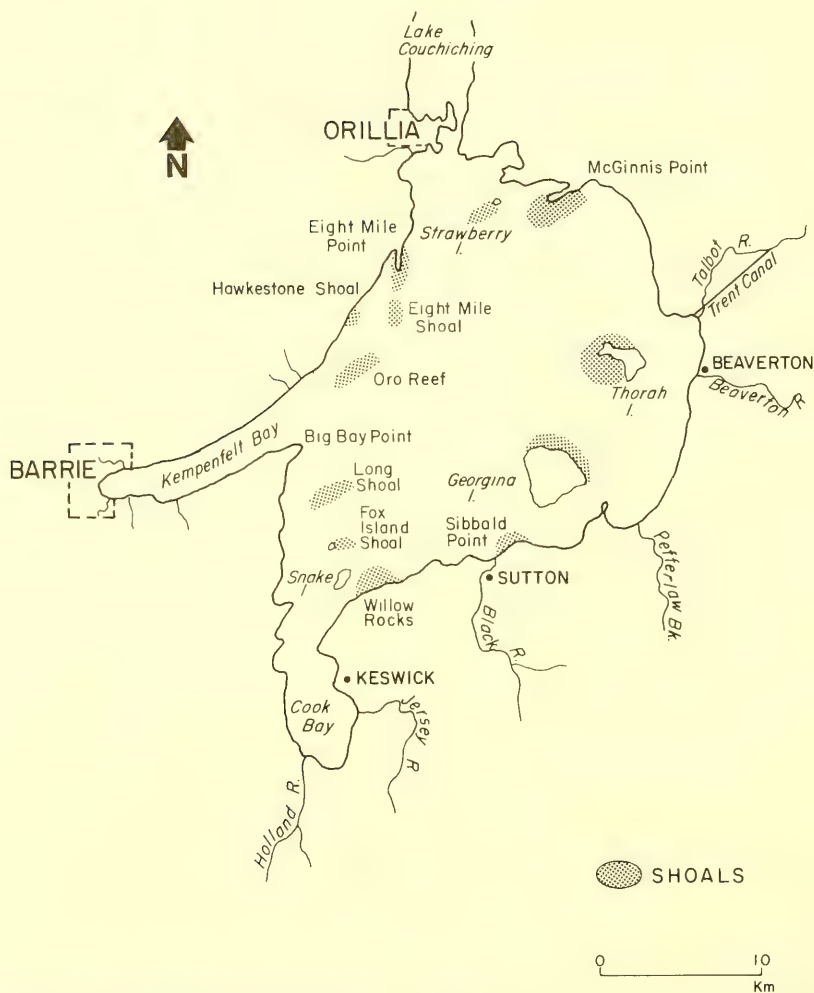


FIGURE 3. Drawing of Lake Simcoe showing the geographical features mentioned in the text.

The consequences of poor recruitment and an aging spawning population are a reduced equilibrium point for the population and an increased risk of collapse, if not imminent extinction. Given this situation, the Ontario Ministry of Natural Resources (OMNR) recommended artificial culture and stocking of yearling whitefish (Evans 1978b, 1979). An experimental stocking program was initiated in 1982. Objectives of stocking are to maintain the Lake Simcoe Whitefish stock until such time that natural reproduction is restored. Eggs are collected and

artificially fertilized using Lake Simcoe parental stock captured each year during the November spawning run.

Habitat

Whitefish spawning shoals in Lake Simcoe consist of cobble-boulder limestone over a sand, clay or bedrock base extending from the shore to a depth of several meters. Twelve such shoals, ranging in area from 7 to 580 ha, have been described in Lake Simcoe (Fulford et al. 1979; Thorn et al. 1979), and similar sites have been

TABLE 1. Population trends for the Lake Simcoe Whitefish, 1963-1983. Catch has been adjusted to a 75 day fishing season and a mean annual effort of 469 709 angler hours per year. Peterson population estimates are based on tag-recapture experiments conducted during 1963 to 1967, 1970, 1973 to 1974 and 1979.

Years	Fork Length mm	Body Weight g	Mean Age y	Angler Catch fish/y	CPUE ^a fish/h	Annual Yield kg/ha	Population Size	Number of whitefish per ha
1963-65	344	428	6.0	155 702	0.323	0.919	1.5 x 10 ⁶	20.7
1966-69	370	543	7.1	162 188	0.353	1.215	1.2 x 10 ⁶	16.6
1970-72	413	784	7.8	62 370	0.133	0.672	9.0 x 10 ⁵	12.4
1973-75	437	939	8.6	26 088	0.059	0.338	6.0 x 10 ⁵	8.3
1976-79	483	1 230	12.3	6 803	0.011	0.115	2.5 x 10 ⁵	3.5
1981-83	499	1 344	10.6	18 419	0.031	0.341	—	—

^aCatch per Unit Effort.

described elsewhere (Machniak 1975). There is much concern that Lake Simcoe is becoming increasingly eutrophic (Ralston et al. 1975). There is clear evidence that siltation and algal growth on spawning shoals has occurred (DesJardine 1979) but the effect, if any, on hatching success of Lake Whitefish is unknown. With periodic algal scums and increase in attached algae occurring on the spawning shoals, the accumulation of decaying matter may reduce the availability of oxygen to developing whitefish embryos within the interstices of the substrate. Excess siltation is thought to have resulted in degradation of the spawning areas of the Lake Simcoe Whitefish (DesJardine and Lawrence 1977), although silt deposition on the shoals does not exceed 5 mm, the level determined by Hindley (1982) to be detrimental to survival. Field observations during the winter revealed that at least some of the shoals were adequate for survival of Lake Whitefish embryos (Hindley 1982).

Limnological surveys in Lake Simcoe indicate that the temperature and dissolved oxygen conditions, particularly during late summer and early fall, are only marginally adequate for survival and well being of Lake Whitefish, although direct evidence of a negative effect on survival has not been obtained.

The diet of the Lake Simcoe Whitefish primarily consists of molluscs, ephemeropterid nymphs (mayflies), and chironomid larvae and pupae (midges), although other invertebrates may also be utilized (Rawson 1930). During the years since Rawson's (1930) study, changes have occurred in the benthic invertebrate community of Lake Simcoe. In general, abundance of the major taxonomic groups of benthic invertebrates has increased, increases being greatest at depths of less

than 15 m. At depths greater than 15 m, most taxa have also increased with the exception of chironomids, which appear to have remained the same, or to have declined slightly (D. O. Evans, unpublished data). Oligochaetes have shown the largest change, being fifty to several hundred times more abundant at all depths.

The primary prey types of the whitefish appear to be at least as abundant at the present time as during the 1920s. Recent estimates of biomass and species composition are not yet available for the benthic invertebrate fauna; however, a species shift combined with the presence of other fish predators may render changes in the benthos less beneficial to Lake Whitefish than the index of numerical abundance might suggest. Qualitative changes in the benthos are consistent with a pattern of progressive nutrient enrichment, as would be expected, given the present inputs from municipal waste disposal and agricultural activities within the Lake Simcoe watershed (Ralston et al. 1975).

General Biology

Spawning occurs in Lake Simcoe on rocky shoals in late October and early November. The exact depth of spawning is difficult to document, but whitefish eggs have been recovered from depths of 2 to 3.1 m in Lake Simcoe (Hindley et al. 1977; Hindley 1982). Water temperatures during spawning are between 3.0 to 4.0°C (Semple 1968). Following spawning the Lake Whitefish typically disperse widely over nearshore areas as indicated by winter catch distributions. The Lake Simcoe Whitefish matures initially at 4+ years with full maturity being attained by 8+ years for both sexes. During 1967 and 1968, 70% of males and females age 4+ years captured at spawning sites were sexually mature (Semple 1968). During the mid

1970s, no 5 or 6 year old whitefish were seen in the fall spawning aggregations (Evans 1978a). Recently (1981 to 1985) a few native fish age 5 and 6 years have appeared, indicating that some recruitment is now occurring.

Fecundity of Lake Simcoe Whitefish was estimated to be 23 175 eggs per female in 1977, as compared to 15 872 eggs per female in 1966, reflecting the increase in mean body weight. Relative fecundity was 21 662 eggs/kg in 1966, compared to 18 498 eggs/kg in 1977 (Semple 1968; Evans 1978a). Whitefish eggs are demersal in nature, lying within the interstices of the spawning shoals until hatching in late April or early May, when the water temperature is 4 to 8°C (Hindley et al. 1977). The incubation period for the Lake Simcoe Whitefish is 150 to 170 days (Ihssen et al. 1981). After hatching, the larval whitefish congregate near the lake surface and commence feeding on zooplankton. In recent years, larvae of the whitefish have been captured in widely separated areas of Lake Simcoe in surface trawls, indicating that spawning and hatching are occurring (DesJardine 1979). Mortality estimates for larval whitefish in Lake Simcoe have not been made. Sampling to date has simply been designed to verify presence or absence, and the relative abundance of larvae in areas adjacent to known spawning shoals.

Growth rate of the Lake Simcoe whitefish has increased significantly in recent years (Evans 1978a). For example, whitefish aged 9+ years in the fall of 1967 had a mean total length of 431 mm and weighed 650 g (Semple 1968), compared to 499 mm and 1 117 g, in the fall of 1977 (Evans 1978a). The Lake Simcoe Whitefish population is comprised of large fish due, not only to accelerated growth, but also to a predominance of old large fish in the population. For example, in 1967, 5+, 6+ and 7+ year old fish, the most prominent age classes, comprised 70% of the spawning population (Semple 1968), while in 1977, the same age classes were completely absent. In 1981, 1982 and 1983, the prominent age classes taken in the winter fishery were 9, 10, 11 and 12 years (Wilcox 1985). The trend of older age groups, making up an increasing percentage of the adult population clearly indicates reduced recruitment to the adult stock.

MacCrimmon and Skobe (1970) reported that the common Lake Simcoe Whitefish is a slow-growing fish which remains relatively small through life, but that a comparatively small population of whitefish is also present in the lake which grows more quickly and attains a greater

size. The large whitefish, to which MacCrimmon and Skobe (1970) made reference, was speculated to possibly be the result of planted non-native hatchery whitefish (Georgian Bay stock) in the lake, although there is no direct evidence (DesJardine and Lawrence 1977). These larger whitefish with a characteristic dorsal hump were locally referred to as "humpbacks". Morphological analyses done by Semple (1968), to determine if two varieties actually existed revealed that the two presumptive types were taxonomically indistinguishable. The hump found in the larger whitefish was concluded to be characteristic of large, old fish and not to be indicative of two stocks of whitefish. Whether or not planting of hatchery reared larvae of the Georgian Bay and Lake Ontario Lake Whitefish stocks resulted in interbreeding with the native Lake Simcoe stock is unknown; however, a recent genetic analysis by Ihssen et al. (1981) indicates that the Lake Simcoe Whitefish is genetically different from the Lake Whitefish stocks of Lake Huron and Lake Ontario.

Hatchery plantings of larval whitefish into Lake Simcoe occurred in 15 different years from 1888 to 1954 (MacCrimmon and Skobe 1970). The numbers released varied from 3000 in 1936 to 5×10^6 in 1953 and 1954, averaging 2.0×10^6 per year over the period. If the natural adult population numbered one million fish (Table 1), 1.125×10^{10} eggs would be produced annually assuming 100% maturity, a sex ratio of 1:1 and 15 000 eggs per female. At an egg survival rate to hatching of 1 to 5 percent, 1.125×10^8 to 5.625×10^8 larval whitefish would be produced. If 5×10^6 larvae of another stock were planted, the transplanted larvae would represent only 0.9 to 4.4 percent of the total larval population. The survival of the planted larvae would undoubtedly be much lower than the wild larvae as a result of accelerated hatchery incubation and handling stress, further reducing the number of viable larvae from the transplanted stocks. Planting occurred in only one year in five from 1900 to 1970, the later date marking the collapse of the whitefish stock. Irregular planting further reduced the potential for genetic exchange between the Lake Simcoe Whitefish and non-native Great Lakes stocks. However, this perceived level of mixing between stocks would probably be sufficient to prevent divergence in the absence of natural selection (Allendorf and Phelps 1981), and also to obscure the effects of genetic drift (Spieth 1974). Therefore, genetic divergence found between the whitefish of Lake Simcoe and those of lakes Huron and Ontario (Ihssen et al. 1981) strongly suggests that

local adaptation may be responsible for genetic differentiation of the Lake Simcoe stock and that planting of the larvae of non-native stocks had little effect. Another possible explanation is that the plantings of larvae had no effect and that the population differences described by Ihssen et al. (1981) represent founder effects. We think the latter explanation is less likely to be true because there is no reason to believe that Lake Simcoe was recolonized independently of Lake Huron and Lake Ontario. Indeed, post-glacial Lake Algonquin, which drained via the Kirkfield outlet to the north of Lake Simcoe, connected the three lakes for thousands of years (Coleman 1941).

Approximately 7 000 years have passed since the most recent continental glaciation and geographical separation of Lake Simcoe from the Laurentian Great Lakes (Prest 1970; Bailey and Smith 1981). Isolation of the Lake Simcoe Whitefish for this period of time is thought to be adequate for local adaptation to occur (P. E. Ihssen, Ontario Ministry of Natural Resources, Maple, Ontario, personal communication). Molecular evolution, which is reflected in protein electrophoresis studies (e.g. Ihssen et al. 1981), proceeds more slowly than organismal evolution as reflected by morphological, physiological and behavioural variation (Clayton 1981). Differential rates in these two evolutionary processes perhaps explains the greater apparent differences between Lake Simcoe Whitefish and other nearby populations when morphological and meristic characters are compared (Ihssen et al. 1981), although it is well known that variation in these characters can be strongly influenced by environmental factors (Martin 1949). However, Lake Simcoe, being at a latitude similar to lakes Huron and Ontario, should have a thermal regime similar to those of the latter two lakes. Hence temperature regimes during the embryonic stages, which can have a marked effect on morphology (Tanning 1952), should be similar for these allopatric stocks. Indeed, similar incubation durations (160 to 167 days) are found for each of these whitefish stocks (Ihssen et al. 1981). The available direct evidence therefore suggests that the Lake Simcoe whitefish is genetically differentiated from nearby whitefish stocks. Several indirect lines of evidence also support this conclusion.

Lake Simcoe is a relatively unique environment, being atypical of other large lakes in Ontario in terms of its water chemistry, morphometry and fish community (Evans and Waring 1987). Thus the lake itself is a unique resource. The diet of the whitefish reflects the limnological uniqueness of

the lake, *Ponteporeia hoyi* and *Mysis relicta*, the primary food resources of whitefish in the Great Lakes, being essentially absent from the diet of the Lake Simcoe Whitefish (Hart 1931). Reduction in the number of gillrakers and pyloric caeca in the Lake Simcoe Whitefish, compared to other nearby stocks (Ihssen et al. 1981), may represent adaptations to the local food supply. Also, recent studies of the Lake Trout, *Salvelinus namaycush*, of Lake Simcoe, which would be expected to have a similar post-glacial history to that of the coinhabiting whitefish, have shown definitively that genetic differences in the retention of swimbladder gas (deep swimming ability) exist between Lake Simcoe Lake Trout and another wild stock (Lake Louisa) located only 125 km away (Ihssen and Tait 1974). This physiological difference was related to differences in the native habitats of the two stocks. The inference that we draw from this is that Lake Simcoe Lake Trout and Lake Whitefish have been geographically separated from other nearby stocks for an adequate period of time for local adaptation to have occurred, and that significant genetic divergence has probably taken place in the stocks of both species as a result of adaptation to local conditions.

Limiting Factors

Since the mid-1960s, the Lake Simcoe Whitefish population has declined by 75 to 85%, angler catch has fallen 80 to 90% (Table 1), and growth rate has increased by 60 to 70% on a body weight basis. The cause or causes of these changes are not known, but several hypotheses have been put forward (Evans 1978a; DesJardine and Lawrence 1979):

1. Reduced spawning success due to physiological or behavioural impairment in adult fish, caused by low oxygen stress during the maturation period prior to spawning.
2. High mortality of embryos on the spawning shoals as a result of siltation, algal growth, predation or a combination of these factors.
3. High mortality of young during the pelagic larval stage due to endogenous or exogenous factors such as chemical contaminants in the yolk, predation or aquatic toxicants, respectively.
4. High mortality of young-of-the-year due to predation, competitive displacement, loss of summer habitat or a combination of these factors.

The primary ecological stresses involved in these hypotheses are eutrophication, contaminants and introduction of Rainbow Smelt, *Osmerus mordax*, the latter being a relatively recent invader.

Eutrophication may operate in several ways to affect Lake Whitefish: by enhancing the production of phytoplankton and attached algae, which in turn may cause degradation of nearshore spawning habitat and also affect the availability of dissolved oxygen in the hypolimnion during summer stratification; by enhancing the production of predators, especially littoral zone predators such as sculpins, *Cottus bairdi*, and crayfish, *Orconectes* spp., that prey upon whitefish eggs during the incubation period; and by causing shifts in species composition or abundance of the plankton and benthos, thereby, possibly affecting the availability or quality of prey items. The general effects of eutrophication have been well documented for Lake Simcoe (Ralston et al. 1975; Evans 1978a), but no direct evidence is available to connect recruitment failure of Lake Simcoe Whitefish to nutrient enrichment.

Contaminants may affect physiological functions of the adults or the survival of the embryos, larvae or young-of-the-year. Contaminants such as DDT, dieldrin, PCBs and mercury are known to be present in the sediments and fishes of Lake Simcoe (Frank et al. 1978). During the period 1971 to 1975, levels of these organic contaminants declined in all species including the Lake Whitefish, whereas mercury levels remained approximately constant. In 1970, DDT levels in the Lake Whitefish muscle tissue and fat were 2.61 and 46.2 $\mu\text{g/g}$, respectively, (Frank et al. 1978), and by 1975, had declined to 0.19 and 6.7 $\mu\text{g/g}$, corresponding with a cessation in the use of DDT in the surrounding area in 1969. Studies on other fish species suggest that the DDT levels in the Lake Simcoe Whitefish during the early 1970s would not have appreciable effects on early survival (Burdick et al. 1964). Similarly, PCB levels which varied from 0.24 to 0.90 $\mu\text{g/g}$ during the same period (Frank et al. 1978) are unlikely to have affected survival of the embryos, larvae or juveniles (Niimi 1983). Dieldrin and mercury levels were also relatively low in the Lake Simcoe Whitefish and were unlikely to have had significant effects (Frank et al. 1978). However, interpretation of the toxicological effects of contaminants is uncertain given the limited information available on the effects of chemicals on Lake Whitefish, and on the possible synergism of multiple contaminants at relatively low concentrations. In support of our interpretation of no effect is the lack of any evidence of unusual mortality or abnormality in eggs, larvae or fry of the Lake Simcoe Whitefish when cultured artificially.

Predation or competition displacement by Rainbow Smelt may be affecting the survival of larvae and young-of-the-year Lake Whitefish in Lake Simcoe. Rainbow Smelt are known to prey on small fish (MacCrimmon and Pugsley 1979), especially during early spring (March), and fall (October, September). Direct evidence of predation on larvae of Lake Whitefish and other coregonines has also been reported (Selgeby et al. 1978; Stedman and Argyle 1985; Loftus and Hulsman 1986), but similar studies have not been conducted on Lake Simcoe.

Rainbow Smelt first appeared in Lake Simcoe in 1961, and by the spring of 1964, were observed spawning in numerous streams entering Lake Simcoe (MacCrimmon et al. 1983). The increase in the smelt population, which reached a peak in 1973, corresponds closely with the decline in the Lake Simcoe Whitefish population (Evans 1978a; Evans and Waring 1987). Similar negative correlations between the abundances of Rainbow Smelt and whitefish have been frequently observed, but a casual relationship has never been clearly established (Anderson and Smith 1971; Evans and Loftus 1987). Evans (1978a,b) speculated that the combined stresses of loss of cold water summer habitat, due to deoxygenation of the hypolimnion, and competition for space or food by Rainbow Smelt, may explain the failure of the Lake Simcoe Whitefish population to recruit any significant year-classes since the mid-1960s.

Special Significance

The Lake Simcoe Whitefish is of special significance for the following reasons:

1. The Lake Simcoe Whitefish has supported the largest winter sports fishery in Ontario, since the early 1900s. During the 1960s, 80% of all winter anglers on Lake Simcoe were seeking Lake Simcoe Whitefish;
2. The estimated 1984 value of the winter fishery for all species is 20 million dollars per year (R. L. DesJardine, Ontario Ministry of Natural Resources, Sutton, Ontario; personal communication). Although a definitive economic study has not been done, this fishery provides 500 000 to 600 000 angler hours of fishing per year.
3. The Lake Simcoe Whitefish is presently the most sought after species in the winter fishery; 58% of all anglers interviewed during creel census surveys in 1981, 1982 and 1983 were seeking this species (Wilcox 1985). The Lake Simcoe Whitefish is a high quality table fish, being largely free of parasites, having very low body burdens of chemical contaminants, and having high palatability.

4. The Lake Simcoe Whitefish stock has a statistically distinctive genetic structure (based on protein electrophoresis), compared to nearby whitefish stocks in the lower Laurentian Great Lakes and on the Haliburton Highlands of the Precambrian Shield of Ontario. Lake Simcoe is limnologically unique and is one of the largest low latitude, alkaline (pH 8.3) lakes in Canada. Morphometric, meristic and diet analyses suggest that the Lake Simcoe Whitefish has diverged genetically from nearby whitefish stocks in response to its local habitat. The Lake Simcoe Whitefish, therefore, appears to represent a uniquely differentiated stock. Given the likelihood that the Lake Simcoe environment is not replicated anywhere in Canada, in contrast to other lake types in environmentally homogeneous areas such as certain parts of the Haliburton Highlands or of the boreal forest of northwestern Ontario, we suggest that it would be prudent to provide special protection for the Lake Simcoe Whitefish.

The threatened status of the Lake Simcoe Whitefish has been recognized for several years (Ralston et al. 1975; Desjardine and Lawrence 1977; Evans 1978a) and management actions have been taken by agencies of the Ontario Government to clearly identify and resolve the problem. A catch limit for anglers was implemented in 1977, no commercial fishery is allowed, water quality controls on domestic sewage discharge have been implemented ensuring tertiary treatment of all municipal inputs, research is underway to identify and minimize inputs of nutrients from agricultural activities, fish stocks and fisheries are actively monitored (e.g. Willox 1985), and a fish culture program has been implemented to develop artificial rearing techniques for Lake Whitefish (Evans 1978a; 1979; Drouin et al. 1985). Since 1982, experimental stocking has been conducted, and field assessment has revealed good survival and growth of the planted yearling whitefish of Lake Simcoe parental origin under the conditions presently existing in Lake Simcoe (Evans, unpublished data).

Recommendations have recently been made to increase the stocking rate to 100 000 yearling whitefish per year (Evans et al. 1985) in the absence of significant natural recruitment. Stocking is considered to be an interim measure to maintain the Lake Simcoe genetic stock at the present minimum population level. Rehabilitation of the stock to self-sustaining status is a goal of the Ontario Ministry of Natural Resources. This will

require additional research into the causative factors underlying the collapse of the whitefish population, and a holistic approach to ecosystem management.

Evaluation

The Lake Simcoe Whitefish population is presently at a precariously low level, and the size and age structures of the population indicate an imbalance between recruitment and mortality. A new much lower equilibrium population size may have been reached compared to pre-1970 levels, but this has not yet been firmly established. Populations at low equilibria are vulnerable to collapse to extinction (Vaughn et al. 1984).

Given the multiple stresses acting on the Lake Simcoe Whitefish population, as discussed above, we consider this fish to be threatened at this time. Given that a species' genetic diversity is a function of the extent of its range and the subdivision of its populations into locally adapted stocks, we suggest that a threat to any one local stock can be construed as a threat to the species. This is especially important if the local stock is representative of a unique gene pool and habitat, as we believe to be the case for the Lake Simcoe Whitefish. Local stocks of this type represent an evolutionary investment which cannot be recreated artificially or simply by substituting another stock, as numerous studies have proved (e.g. Bams 1976; Plosila 1977; MacLean et al. 1981). In view of the perceived importance of genetic diversity (Josephson 1982; Meyers 1984; Meffe 1986) and the evidence of local adaptation and uniqueness as summarized herein, we strongly recommend that special status be afforded the Lake Simcoe Whitefish.

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Status of the Squanga Whitefish, *Coregonus* sp., in the Yukon Territory, Canada*

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The Squanga Whitefish (*Coregonus* sp.) is presently known to exist in only four lakes in the Yukon Territory, Canada. It occurs sympatrically with the Lake Whitefish (*Coregonus clupeaformis*) in all four lakes. It is distinguished from the Lake Whitefish (its closest relative) by higher gill raker counts. Populations of the Squanga Whitefish are genetically distinct from sympatric Lake Whitefish in both morphology and proteins, and the two forms are probably wholly or substantially reproductively isolated. Squanga Whitefish are obligate planktivores for the whole of their lives, and are apparently susceptible to competition from ciscos (*Coregonus sardinella* and others). The Squanga Whitefish does not occur sympatrically with ciscos. All populations of the Squanga Whitefish are probably not all monophyletic and each represents a unique genetic stock worthy of protection. A status of "rare" is recommended.

Le Corégone du squanga (*Coregonus* sp.) n'a été signalé que dans quatre lacs du Territoire du Yukon (Canada) où il vit en sympatrie avec le Grand corégone (*Coregonus clupeaformis*), son plus proche congénère, dont il se distingue par son nombre plus élevé de branchiostèmes. Au niveau génétique, les populations sympatriques de Corégone du squanga et de Grand corégone sont différentes pour ce qui est de la morphologie et des protéines et il est probable que les deux formes sont complètement ou très isolées au niveau de reproduction. Le Corégone du squanga est strictement planctivore pendant tout son cycle vital; il semble être sensible à la compétition avec les ciscos (*Coregonus sardinella* et autres) quoiqu'il ne vive pas en sympatrie avec ceux-ci. Les populations de Corégone du squanga ne sont probablement pas toutes monophylétiques et chacune représente un stock génétique unique qui mérite d'être protégé. Les auteurs recommandent que le Corégone du squanga soit considéré comme rare.

Key Words: Squanga Whitefish, *Coregonus*, Yukon Territory, distribution, population size, electrophoresis, rare, whitefish, genetics.

The coregonid fish fauna of four lakes in the southern Yukon Territory consists of populations of *Coregonus* which are notable because gill raker counts are bimodal. The form with higher gill raker counts exists only in the absence of ciscos. In this report, a number of ecological, anatomical and biochemical characteristics of these atypical *Coregonus* populations will be described. The data support the view that the *Coregonus* form with the lower gill raker count is not distinguishable from the form of Lake Whitefish (*Coregonus clupeaformis*) that is widely distributed in Yukon Territory lakes in both the presence and absence of the Least Cisco, *Coregonus sardinella*, [Lindsey et al. 1981]. The higher gill raker count form has been found only as a member of a sympatric pair of forms and it will be shown that this form (Figure 1), together with the ecosystems that support and maintain it are rare entities worthy of preservation and further study.

The atypical stocks of *Coregonus* with bimodal distributions of gillraker counts were first described by Wynne-Edwards (1952) from Squanga Lake. He referred to the "squanga"†, which he noted was characterized by high gill raker counts and strong spawning tubercles. He referred also to the low gill raker count form: "At Squanga Lake the Common Whitefish (*nelsoni*) is also present, but the two are said to have different spawning beds". The name Squanga Whitefish has also been recently used to describe the high gill raker count form (McAllister et al. 1985). This name will also be used here, but we will defer from suggesting that the Squanga Whitefish is a species as McAllister et al. (1985) have recently done, primarily because the known populations of the Squanga Whitefish may not be a monophyletic group.

*Rare status approved and assigned by COSEWIC 7 April 1987.

†The word squanga (pronounced skwong'ga) is derived from the local Indian name for the fish. The meaning of the word is not known.



FIGURE 1. Photograph of Squanga Whitefish from Dezadeash Lake.

Distribution

The Squanga Whitefish is known at present from only four lakes in the Yukon Territory, Canada (Bodaly 1979). It is not found outside of Canada. The four lakes (Figure 2) are Dezadeash, located in the Alsek drainage basin in southwest Yukon Territory, and Squanga, Little Teslin and Teenah, located in the Squanga Creek drainage system, tributary to the Yukon River in south central Yukon Territory. The Squanga Whitefish also existed in Hanson Lake, but in 1963 the fish fauna of this lake was poisoned to prepare the lake for Rainbow Trout (*Salmo gairdneri*) planting (Bodaly 1979). Squanga Whitefish may also exist in Tatchun Lake (Lindsey 1981; see below). Hanson and Tatchun Lakes are located in the Yukon River basin in central Yukon Territory (Figure 1).

Taxonomic Status

The discussion in this section will centre on demonstrating that the Squanga Whitefish is a

unique genetic form which is wholly or substantially reproductively isolated from all other coregonid fishes.

The Squanga Whitefish always occurs sympatrically with populations of the Lake Whitefish, a very similar form which is probably its closest relative. The presence of Squanga Whitefish in a given lake is usually revealed by examination of the gill raker count distribution of *Coregonus* (excluding ciscos and Broad Whitefish, *Coregonus nasus*) in the lake; a bimodal distribution is indicative of two forms of fish. The gill raker count distributions of *Coregonus* in Dezadeash, Squanga, Teenah, Little Teslin and Tatchun Lakes are shown in Figure 3. The lower modes in the first four lakes are similar to populations of Lake Whitefish from other Yukon Territory lakes. Those fish in the higher mode are designated as Squanga Whitefish.

The gill raker number distribution of *Coregonus* from Tatchun Lake is not strongly bimodal but is suggestive of the presence of two forms because it

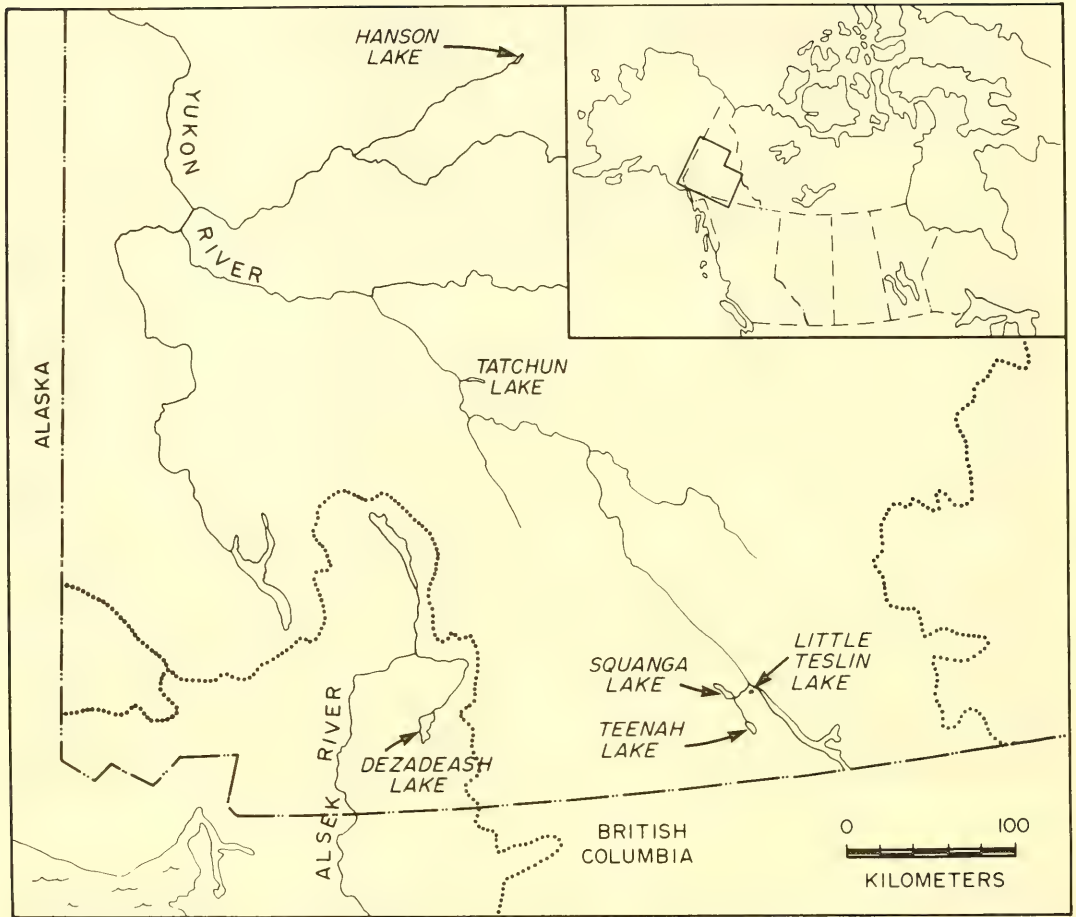


FIGURE 2. Map of southern Yukon Territory showing lakes in which the Squanga Whitefish probably occurs (or occurred) and limits of Yukon River and Alsek River basins.

extends over a much greater range of gill raker numbers than is usual for most populations of Lake Whitefish in the Yukon Territory (Figure 3). Also, *Coregonus* from this lake are bimodal with respect to gill raker length (Lindsey 1981), another character known to differ between Lake Whitefish and Squanga Whitefish.

Aside from the gill raker apparatus, Squanga Whitefish are morphologically extremely similar to Lake Whitefish. Despite the very obvious external similarity between Squanga Whitefish and the sympatric Lake Whitefish, Bodaly (1979) has shown that statistically significant differences do exist for such morphological characters as gill raker length, distance between gill rakers, size of

the head and length of the fins relative to the size of the body.

Similar sympatric pairs of *Coregonus* are known from lakes in Maine (Fenderson 1964; Kirkpatrick and Selander 1979), in Gabbro and Ossokmanuan Lakes, Labrador (Bruce 1984), from Lac Témiscouata, Québec (Lindsey 1979), from Opeongo Lake, Ontario (Kennedy 1943; P. E. Ihssen, Ontario Ministry of Natural Resources, Fisheries Research, Maple, Ontario, personal communication) and other lakes in Ontario and Quebec and were known from Dragon Lake, British Columbia (Lindsey et al. 1970). However, the Squanga Whitefish is not closely related to any member of these other populations. Lindsey et al.

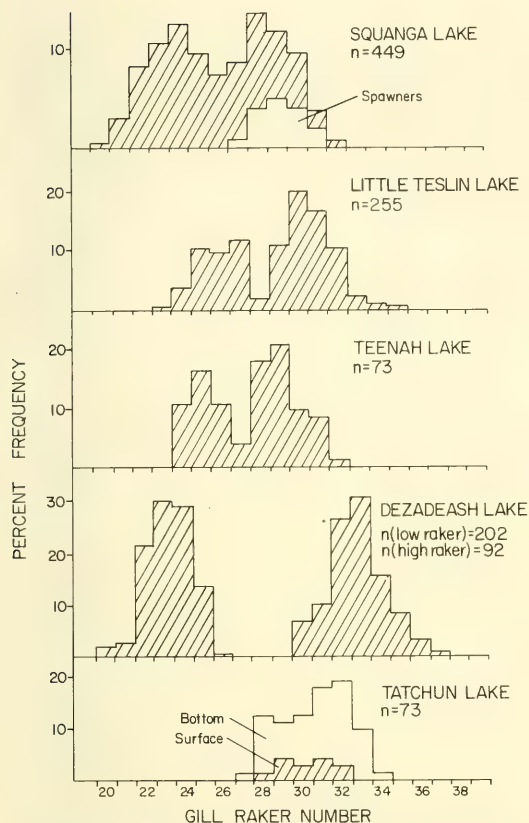


FIGURE 3. Gill raker distributions for Lake and Squanga Whitefish from Yukon Territory lakes.

(1970) and Franzin and Clayton (1977) have shown that Lake Whitefish in western Canada originated in two different glacial refugia and that their isozyme composition differs depending on refugium of origin. Evidently the ancestors of all Lake Whitefish presently found in the Yukon survived Wisconsin glaciation and possibly earlier glacial maxima in the Bering refugium. Lindsey et al. (1970) demonstrated that Squanga Whitefish found in Squanga Lake are also of Bering refugium origin based on the examination of hemoglobin, lactate dehydrogenase (LDH), and glycerol-3-phosphate dehydrogenase (G-3-PDH) isozymes. Bodaly (1977) showed that the Squanga Whitefish of Dezadeash, Little Teslin, and Teenah Lakes are also derived from Bering refugium stocks based on the examination of LDH and G-3-PDH isozymes. Also, the following new evidence concerning malate dehydrogenase (MDH) allele frequencies

confirms these earlier studies. At one mitochondrial MDH locus all Lake Whitefish descended from Mississippi/Missouri refugium stocks are fixed for a single common allele (J. W. Clayton, unpublished data), while many Lake Whitefish of Bering refugium origin and Squanga Whitefish from Dezadeash Lake (Table 1) are polymorphic at this locus. Furthermore, at loci representing cytoplasmic *mdhA* and *mdhB* loci (Bailey et al. 1970), Bering refugium origin Lake Whitefish and Squanga Whitefish are monomorphic for a single allele at the *mdhB* loci, but polymorphic at the *mdhA* loci (Table 1). In contrast, Lake Whitefish of Mississippi/Missouri refugium origin are monomorphic at the *mdhA* loci and are polymorphic at the *mdhB* loci. Thus, the Squanga Whitefish of the Yukon Territory are not closely related to other dwarf or unusual *Coregonus* forms which occur sympatrically with Lake Whitefish in other parts of North America. Their relationship to the two sympatric forms which occupy some lakes in Siberia (Reshetnikov 1975) is unknown.

In the four Yukon lakes in which they coexist, Squanga Whitefish and Lake Whitefish are characterized by a high degree of reproductive isolation. Three areas of evidence will be discussed: genetic differences in morphology and proteins, segregation at spawning, and the rarity of apparent hybrids.

Gill raker number is largely genetically determined (Svårdson 1970), although slight environmental modification is possible (Lindsey 1981). The differences in gill raker number between sympatric Squanga and Lake Whitefish are large enough to indicate genetic differences. Other morphological differences between the Squanga Whitefish and the Lake Whitefish may be the result of environmental modification or genetic differences (Bodaly 1979).

The Squanga and Lake Whitefish sympatric pairs in Squanga, Teenah, Little Teslin, and Dezadeash lakes also have significantly different allele frequencies at either the *ldhMB* or the *s-idha* loci (Table 1). Frequencies of bands visualized by general protein stains of white muscle extracts fractionated on isoelectric focussing gels are similar for Squanga and Lake Whitefish in Squanga, Little Teslin, and Teenah lakes. In contrast, the differences in the frequency of band B between Squanga Whitefish and Lake Whitefish from Dezadeash Lake (Table 2) evidently reflects a genetic difference between these populations. Thus, Squanga Whitefish and Lake Whitefish from all four Yukon lakes show genetic differences based on gill raker number and biochemical

TABLE 1. Lactate dehydrogenase (*ldhM β -1*), glycerol-3-phosphate dehydrogenase (*g-3-pdhA-1* and *g-3-pdhB-2*), isocitrate dehydrogenase (*s-idh α*), and malate dehydrogenase (*s-mdhA*($\alpha + \beta$)-1, *s-mdhB*($\alpha + \beta$)-2, and *m-mdhY*(β -2) allele frequencies in Squanga Whitefish and Lake Whitefish from Squanga, Little Teslin, Teenah and Dezadeash lakes, Yukon Territory. For the two allele *ldh*, *g-3-pdh*, and *mdh* loci only the frequency of the less common allele is presented. The number of fish examined for each enzyme system is given in brackets. Asterisks (*) indicate that significant differences ($P < 0.05$) exist between Squanga and Lake Whitefish for number of alleles for that enzyme in that lake (chi squared test of contingency tables of numbers of alleles). See Bodaly (1977); Cross and Ward (1980); Casselman et al. (1981); and Bailey et al. (1976) for genetic models and nomenclature.

	Squanga Whitefish				Lake Whitefish			
	Squanga	Little Teslin	Teenah	Dezadeash	Squanga	Little Teslin	Teenah	Dezadeash
<i>ldhMβ-1</i>	0 (13)	0.02 (21)	0* (27)	0.05 (38)	0.06 (8)	0.12 (17)	0.08* (6)	0.11 (23)
<i>g-3-pdhA-1</i>	0.21 (159)	0.21 (77)	0.23 (112)	0.04 (51)	0.21 (120)	0.18 (86)	0.27 (33)	0.02 (25)
<i>g-3-pdhB-2</i>	0.45* (159)	0.34 (77)	0.42 (112)	0.45 (51)	0.33* (120)	0.31 (86)	0.48 (33)	0.38 (25)
<i>s-idhα-1</i>	0.04* (56)	0.16* (72)	0.09 (28)	0.06* (63)	0.01* (40)	0.12* (80)	0 (6)	0.06* (112)
<i>s-idhα-2</i>	0.05* (56)	0.08* (72)	0.14 (28)	0.21* (63)	0.20* (40)	0.41* (80)	0.33 (6)	0.69* (112)
<i>s-idhα-3</i>	0.90* (56)	0.76* (72)	0.77 (28)	0.74* (63)	0.79* (40)	0.48* (80)	0.67 (6)	0.25* (112)
<i>s-mdhB</i> ($\alpha + \beta$)-2	1.00 (132)	1.00 (12)	1.00 (106)	1.00 (111)	1.00 (101)	1.00 (24)	1.00 (32)	1.00 (85)
<i>s-mdhA</i> ($\alpha + \beta$)-1	0.13 (132)	0.04 (12)	0.15* (106)	0.37 (111)	0.17 (101)	0.01 (24)	0.10* (32)	0.35 (85)
<i>m-mdhYβ-2</i>	0 (132)	0 (12)	0 (106)	0.14 (111)	0 (101)	0 (24)	0 (32)	0.18* (85)

genetic characters, but only in Dezadeash Lake are gill raker distributions non-overlapping. Therefore, while present evidence suggests no gene flow between the two whitefish forms in Dezadeash Lake, it is possible that there is a very low rate of gene flow between the populations present in Little Teslin, Teenah, and Squanga lakes.

Pre-mating isolating mechanisms (separation of the populations at spawning time) between Squanga Whitefish and Lake Whitefish are probably strongly developed in all four Yukon lakes in which the two forms coexist. Evidence for physical separation between Squanga Whitefish and Lake Whitefish at spawning time is available for Squanga Lake. Lindsey (1963) presented gill raker counts of fish caught in inlet and outlet streams in November and December of 1934 and 1960. All of these fish had gill raker counts (Figure 3) characteristic of Squanga Whitefish (Lindsey 1963). Where and when the Lake Whitefish from Squanga Lake spawn is unknown. On the basis of an examination of the size of developing eggs, Bodaly (1977) suggested that some overlap in the spawning season of Squanga and Lake Whitefish from Little Teslin and Teenah lakes was possible,

but that the spawning times of these two forms in Dezadeash Lake probably did not overlap. Fish that can be identified, on the basis of morphological characteristics, as possible hybrids between Squanga Whitefish and Lake Whitefish are found in Squanga, Little Teslin and Teenah lakes but not in Dezadeash Lake. The proportion of fish which were suspected to be hybrids (out of the total of Squanga and Lake Whitefish which were examined) were 0% in Dezadeash, 1 to 2% in Little Teslin, and 4 to 5% in Teenah and Squanga lakes (Bodaly 1977). One suspected hybrid fish was identified from a spawning run of Squanga Whitefish from Squanga Lake (Bodaly 1977). This low level of hybridization is probably not an indication of the beginning of a mass hybridization. Many instances of closely related sympatric coregonid populations which hybridize to some extent are known, but these have remained stable (Svårdson 1952). As well, our sampling has shown that the population structure in Squanga Lake has remained stable for at least 18 years (1960 to 1978). Squanga and Lake Whitefish are evidently able to coexist in Squanga, Little Teslin, and Teenah lakes despite a low level of hybridization. In Dezadeash Lake, reproductive isolation is complete.

TABLE 2. Frequency of certain protein bands on isoelectric focussing gels from Squanga Whitefish and Lake Whitefish from Squanga, Little Teslin, Teenah, and Dezadeash lakes, Yukon Territory.

	Squanga Whitefish				Lake Whitefish			
	Squanga	Little Teslin	Teenah	Dezadeash	Squanga	Little Teslin	Teenah	Dezadeash
Number of samples	39	30	16	19	13	26	9	41
Band A	1.00	0.87	0.94	0.47	0.92	0.96	0.89	0.51
Band B	0.03	0.00	0.06	0.05	0.00	0.00	0.00	0.39
Band C	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.10

Regarding nomenclature, diverse opinions have been expressed earlier about the two sympatric forms in Squanga Lake. Wynne-Edwards (1952) stated the low gill raker form was *Coregonus nelsoni*. Walters (1955) stated that the Squanga was *Coregonus clupeaformis* and the other form was uncertain. Lindsey (1963) suggested that the Squanga should probably be called *Coregonus clupeaformis*, and the low raker form *Coregonus pidschian*. These opinions were based on less extensive data than are now available.

While it is now clear that the form with the lower gill raker count corresponds to the Lake Whitefish, whether the Squanga Whitefish is a monophyletic species is not clear. A number of lines of evidence can be brought to bear on the question of the possible monophyletic nature of the Squanga Whitefish, such as feeding behaviour, population characteristics, morphology, and biochemical genetic characters. Of these, only biochemical genetic characters will probably provide reliable indicators of relatedness since they are genetically based and are probably relatively unaffected by selection. Other characters, such as behaviour and morphology are either strongly affected by selection or are not directly genetically controlled. Most of the behavioural and morphological differences evident between Squanga Whitefish and sympatric Lake Whitefish are probably a set of co-adapted traits which are associated with the feeding behaviour of planktivory in the Squanga Whitefish. Such differences include the gill raker apparatus and spatial distribution of fish in relation to the lake bottom. Differences in growth, longevity and age at first maturity may also be related to planktivory. Differences in the relative lengths of various body parts are likely due to environmental effects because they occur as sets of differences (i.e. smaller heads, eyes and fins) as is the case when morphological differences are known to be the result of environmental effects

(Bodaly 1979). Also, these differences in the size of various body parts of Squanga and Lake Whitefish were not consistent between lakes and were therefore not consistent with known ecological differences (Bodaly 1979).

Biochemical genetic evidence suggests that the Squanga Whitefish are not a monophyletic group and that the Squanga Whitefish presently found in Dezadeash Lake have an independent origin from the populations found in the Squanga Creek drainage basin (Squanga, Little Teslin, and Teenah lakes). The Squanga Whitefish and Lake Whitefish of Dezadeash Lake are biochemically distinct from those in the Squanga Creek system in *g-3-pdhA* and *s-mdhA* allele frequencies and an allele at the *m-mdhYβ* locus is present in the Dezadeash fish which is not found in Squanga or Lake Whitefish in the Squanga Creek system (Table 1). The Squanga and Lake Whitefish of Dezadeash Lake also differ from those found in the

TABLE 3. Relative abundance of Squanga Whitefish in Squanga Lake, Yukon Territory. Shallow (onshore) sets in mean depths of 1–5 m; deep sets on bottom in 8–40 m; floating sets on surface over 12–24 m. Catch per unit effort given as number of fish caught per hour of fishing. Shallow and deep areas were fished by an experimental gill net 60 m long and 2.4 m deep, with 5 panels 38, 63, 89, 51 and 76 mm stretched mesh monofilament nylon. Floating sets were each 46 m long and 7.6 m deep, with 3 panels of 38, 51 and 63 mm stretched mesh monofilament nylon.

Season	Time of day	Net position	Catch per unit effort
Early summer (7–18 June 1960)	day	shallow	1.22
		deep	1.68
		floating	3.62
	overnight	floating	2.32

TABLE 4. Relative abundance of Squanga Whitefish in Little Teslin Lake, Yukon Territory. Shallow (onshore) sets in 2 m of water; deep and floating sets in 17 m of water. Catch per unit effort given as number of fish caught per hour of fishing. Net type utilized as in Table 6.

Season	Time of day	Net position	Catch per unit effort
Early summer (26-27 June 1975)	day	shallow	0.11
		deep	1.63
		floating	0.74
	overnight	shallow	0.27
		deep	0.88
		floating	4.04
Late summer (27-28 August 1975)	overnight	shallow	0.19
		deep	0.29
		floating	2.92

Squanga Creek system in the frequency of protein band "A" revealed by isoelectric focussing (Table 2). As well, another unique protein (band "C"), revealed by isoelectric focussing, is found in *Coregonus* of Dezadeash Lake but not in *Coregonus* in the Squanga Creek system (Table 2).

Protection

There have not been any formal protective measures or policies put in place for populations of the Squanga Whitefish. The presence of Squanga Whitefish was recognized and considered in the proceedings of the Alaska Highway Pipeline Environmental Assessment Panel (Environmental Assessment Alaska Highway Pipeline 1977). In submissions to this panel, Hayden (1977) and Northern Natural Resource Services Ltd. (1977) described the presence of Squanga Whitefish in Squanga and Little Teslin Lakes and recommended special consideration be given these lakes during pipeline routing and construction. The

TABLE 5. Relative abundance of Squanga Whitefish in Teenah Lake, Yukon Territory. Shallow (onshore) sets in 2 m of water; deep and floating sets in 18 m of water. Catch per unit effort given as number of fish caught per hour of fishing. Net type utilized as in Table 6.

Season	Time of day	Net position	Catch per unit effort
Early summer (8-9 July 1970)	overnight	shallow	3.50
		deep	0.35
		floating	7.13

TABLE 6. Relative abundance of Squanga Whitefish in Dezadeash Lake, Yukon Territory. Shallow (onshore) sets in 2.1 m of water; deep and floating sets in 4.2 m of water. Catch per unit effort given as number of fish caught per hour of fishing. The net used was an experimental gill net 38.1 m long and 2.1 m deep with successive panels, of 24, 41, 76, 38, and 64 mm stretch mesh monofilament nylon.

Season	Time of day	Net position	Catch per unit effort
Late spring (6-15 June 1974)	light	shallow	0.17
		deep	0.13
		floating	0
	dark and overnight	shallow	2.00
		deep	0.45
		floating	0.09
Early summer (26 June-1 July 1974)	light	shallow	0.92
		deep	0.22
		floating	0.89
	dark	shallow	1.25
		deep	1.00
		floating	8.67
Mid summer (26 July-2 August 1974)	light	shallow	0
		deep	2.00
		floating	0
	dark	shallow	4.00
		deep	3.00
		floating	4.00
Late summer (10-26 August 1974)	light	shallow	0.50
		deep	1.20
		floating	5.43
	dark and overnight	shallow	1.26
		deep	0.43
		floating	4.68

interim report of the panel (Fisheries and Environment Canada 1977) concluded that additional detailed environmental assessments were required in the Squanga Lake area to determine an acceptable pipeline route. The final report of this panel (Environmental Assessment Panel, Alaska Highway Gas Pipeline 1982) noted that the project proponent had revised the preferred route away from Squanga Lake, to the south of both Squanga and Little Teslin lakes. The Environmental Assessment Panel agreed with this routing relocation. A number of recommendations for technical procedures during stream crossings were also noted by the Environmental Assessment Panel (Environmental Assessment Panel, Alaska Highway Gas Pipeline 1982).

TABLE 7. Physical and biological characteristics of Squanga, Little Teslin, Teenah and Dezadeash lakes, Yukon Territory. Data from Lindsey et al. (1981); see for sampling details.

	Squanga	Little Teslin	Teenah	Dezadeash
Elevation (m a.s.l.)	790	790	885	915
Surface area (km ²)	11.1	3.2	2.5	77.2
Maximum known depth (m)	40	20	19.2	7.6
Secchi transparency (m)	4.0	4.0–5.5	4.3	0.6–4.0
Chlorophyll-a (μ g per L)	–	1.33–1.90	–	1.34
pH	8.0	–	8.0	8.0
Total dissolved solids (mg per L)	160–243	150–170	150	90–100
Conductivity (μ S per cm)	260	200	200	120
Hardness (mg CaCO ₃ per L)	137	137	154	62
Total zooplankton abundance (mg per cm ²)	–	4.43–4.66	–	1.3
No. crustacean zooplankton per cm ²	51.7	26.0	140	–
No. crustacean zooplankton per L	43.0	18.0	77.7	41.4

Population Size and Trend

Squanga Whitefish are relatively abundant in all four southern Yukon lakes in which they are presently found. Actual estimates of numbers are not available but catch per unit effort values for gill net catches are known for all lakes (Lindsey 1963; Bodaly 1977, 1979). These data are presented in Tables 3, 4, 5 and 6 for Squanga, Little Teslin, Teenah and Dezadeash lakes. These estimates of catch per unit effort are for only one or two (successive) years for each lake. Therefore, changes in the abundance of the Squanga Whitefish in these lakes are not known. They may be assumed to be quite small and due largely to natural causes, however, because man-induced environmental changes on these lakes are probably limited. Teenah Lake is not road accessible and is probably in pristine condition. Squanga, Little Teslin, and Dezadeash lakes are road accessible; the major human activities on these lakes are small tourist developments, angling, and for Squanga and Dezadeash lakes, small domestic fisheries. These activities have probably not had a major effect on whitefish in these lakes.

The limited distribution of the Squanga Whitefish is natural, with the exception of the poisoning of the Hansen Lake population, and the form has probably been restricted to a small number of lakes in the Yukon at least since the recession of Wisconsin glaciers. The Squanga Whitefish apparently cannot compete effectively with the Cisco *Coregonus sardinella*. Ciscos have a wide distribution in the Yukon (Lindsey et al. 1981) and the Squanga Whitefish has been restricted to local drainage basins in which ciscos have not become established (see below).

Habitat

Habitat Description: The physical and biological characteristics of the four southern Yukon Territory lakes in which Squanga Whitefish occur are summarized in Table 7. The most striking common ecological feature of these lakes is that the Least Cisco is absent from all four. The Least Cisco is common throughout the Yukon Territory but is absent in the Alsek River basin (including Dezadeash Lake), the Squanga Creek drainage system (including Squanga, Little Teslin, and Teenah lakes), and is also absent from the South McQuesten River system (including Hanson Lake). With the exception of Hanson Lake, all lakes which support or supported Squanga Whitefish have extensive littoral areas. Twenty-one percent of the surface area of Squanga Lake has a depth of less than 3 m (Lindsey 1963), over half of Little Teslin Lake is less than 10 m in depth, spot soundings in Teenah Lake revealed fairly extensive shallow areas (C. C. Lindsey, unpublished data) and the maximum depth of Dezadeash Lake is less than 10 m (Bodaly 1977). Another common feature of lakes which support Squanga Whitefish is low abundance of piscivorous fish (Table 8). The only predators in Squanga Lake are *Lota* and *Esox* and neither is abundant (Lindsey 1963). *Lota* is the only predator in Little Teslin Lake and it is not abundant while *Esox* is the only predator found in Teenah Lake. J. S. Nelson (Department of Zoology, University of Alberta, unpublished data) indicated that *Esox* were relatively numerous in Hanson Lake, although it was probably the only piscivorous fish present before poisoning. In Dezadeash Lake, *Salvelinus namaycush* is moderately abundant in restricted

TABLE 8. Fish species present in Squanga, Little Teslin, Teenah and Dezadeash lakes, Yukon Territory. From Lindsey et al. (1981).

	Squanga	Little Teslin	Teenah	Dezadeash
<i>Coregonus clupeaformis</i>	x	x	x	x
Squanga Whitefish	x	x	x	x
<i>Prosopium cylindraceum</i>				x
<i>Thymallus arcticus</i>	x		x	x
<i>Salvelinus namaycush</i>				x
<i>Esox lucius</i>	x		x	x
<i>Catostomus catostomus</i>		x		x
<i>Lota lota</i>	x	x		x
<i>Cottus cognatus</i>	x	x	x	x

areas while *Esox* and *Lota* are rare. The particular limnological features of these lakes have apparently contributed to their suitability to support populations of the Squanga Whitefish.

Habitat Utilization: Squanga Whitefish utilize all parts of the water column, although in summer they are usually most abundant in the pelagic zone (Tables 3-6). Squanga Whitefish utilize mainly pelagic and surface food, such as zooplankton and chironomid pupae. Crustacean zooplankton are the dominant food items. Feeding patterns of Squanga Whitefish are discussed in detail in Bodaly (1979).

Protection of Habitats: All habitat of the Squanga Whitefish is aquatic and is therefore under ownership of the Crown.

The level of protection of Squanga Whitefish habitat appears to have been adequate to date aside from Hanson Lake which was poisoned, but the level of protection in the future will depend on continued vigilance against habitat degradation, poisoning, and the introduction of predators and competitors. The Squanga Whitefish is undoubtedly susceptible to all forms of habitat degradation to which other coldwater forms are vulnerable. These include thermal pollution, alteration of spawning beds, siltation of spawning beds, poisoning, severe water level fluctuations, high levels of suspended sediments which could interfere with sight feeding and any other disturbances which would severely limit food supply (in this case, zooplankton productivity). In addition, the Squanga Whitefish appears to be particularly vulnerable to a few specific habitat alterations. The Squanga Whitefish is an obligate planktivore throughout its life and apparently is not able to coexist with ciscos, which are also planktivores. Presumably, ciscos are able to more effectively utilize zooplankton as a food source and

their introduction into a lake which supported Squanga Whitefish would probably lead either to a severe reduction in Squanga Whitefish numbers or to complete elimination of the Squanga Whitefish from that lake. In Lake Opeongo, which supports a dwarf Lake Whitefish-like form with characteristics similar to the Squanga Whitefish, the introduction of a cisco species led to a severe reduction in the numbers of the dwarf form (Lindsey 1981). Squanga Whitefish may also be susceptible to dense populations of predatory fish and the introduction of new piscivorous fish (eg. *Salvelinus namaycush* into lakes in the Squanga Creek drainage system) could reduce Squanga Whitefish populations significantly.

One method of increasing protection for Squanga Whitefish would be to consider introductions of the form into waters in which it is not presently found. It could be introduced into Hanson Lake, where it once existed. Any candidate lakes would have to be carefully considered based on available food, lack of competitors, and abundance of predators. Introducing Squanga Whitefish into waters where they are not presently found may also aid in the study of this distinctive form.

General Biology

Reproductive Capability: In general, the Squanga Whitefish is an early maturing fish with a relatively short life span. The age at first maturity for Squanga Whitefish ranges from 2 to 5 years (Table 9). In Little Teslin Lake, Squanga Whitefish are first mature at 2 years of age and almost all males and females are mature by 3 years of age. In Dezadeash Lake, some Squanga Whitefish mature at 4 years of age while all males and females were mature at 5 years of age. In Teenah Lake, most 3 year old fish are mature; all Squanga Whitefish captured from this lake were mature (with the

TABLE 9. Proportion of mature Squanga Whitefish by age from Little Teslin and Dezadeash lakes, Yukon Territory. Number of fish given in brackets. See Bodaly (1977) for sampling methods and times, aging techniques and criteria utilized to determine maturity.

Age	Little Teslin			Dezadeash		
	males	females	immature (sex unknown)	males	females	immature (sex unknown)
0			(1)			(6)
1			(1)			(24)
2	0.25 (8)	0.75 (8)		0.00 (2)	0.00 (7)	(13)
3	1.00 (31)	1.00 (33)	(1)	0.00 (3)	0.00 (5)	(3)
4	1.00 (32)	1.00 (5)		0.73 (15)	0.75 (12)	(3)
5	1.00 (4)	1.00 (5)		1.00 (12)	1.00 (8)	
6					1.00 (1)	

exception of one fish of unknown sex which was 3 years old) and these mature fish ranged in age from 3 to 6 years of age. It should be noted that fish ages were determined from scales for the estimation of age at first maturity, age distributions and growth rates for this report. It has been shown by Mills and Beamish (1980) that ages read from scales tend to underestimate the true ages of unexploited Lake Whitefish. For the coregonid fishes of Dezadeash Lake, it was shown that ages determined from fin-ray sections were greater than ages determined from scales for 77% of fish sampled (Mills and Beamish 1980).

The frequency of Squanga Whitefish spawning is probably annual. There is no indication of reproduction at intervals less frequent than annual once maturity is reached in Dezadeash, Squanga, Little Teslin, and Teenah Lakes (Lindsey 1963; Bodaly 1977). The fecundity of the Squanga Whitefish has not been determined.

Modal ages for Squanga Whitefish ranged from 3 to 5 years in Little Teslin, Dezadeash, and Teenah Lakes (Table 10). Most individuals were 5 years of age or less and no fish older than 7 were captured. Growth rates of Squanga Whitefish from Dezadeash and Little Teslin Lakes were presented in Bodaly (1979). The sex ratio in populations of Squanga Whitefish is usually near unity or slightly favors females. In Little Teslin Lake, the sex ratio was 1.03 males per female (sample size = 148), in Teenah Lake the sex ratio was 0.67 males per female (sample size = 30), and in Dezadeash Lake the sex ratio was 0.86 males per female (sample size = 180; R. A. Bodaly, unpublished data).

The spawning behaviour of the Squanga Whitefish is not known. It is probably similar to

other closely related coregonid species such as the Lake Whitefish. The Lake Whitefish is a broadcast spawner, with fertilization taking place in the water column. The eggs are denser than water and settle to the bottom. There is no parental care. Preferred substrates for most coregonid fishes are sandy or rocky bottoms. It is known that the Squanga Whitefish of Squanga Lake spawn in inlet and outlet streams but whether all the Squanga Whitefish of this lake are stream spawners (some could be lake spawners) or whether the Squanga Whitefish of other lakes are stream spawners is not known. The Squanga Whitefish of Little Teslin Lake probably spawn within the lake itself because this lake has no large inlet streams.

Species Movement: The Squanga Whitefish is apparently not migratory and probably occupies lake habitat throughout the year, with the exception of spawning time in at least one lake

TABLE 10. Age frequency distributions for Squanga Whitefish from Little Teslin, Teenah and Dezadeash lakes, Yukon Territory. (R. A. Bodaly, unpublished data). Numbers given as percent frequency. See Bodaly (1977) for details of sampling methods and periods.

Age	Little Teslin (n = 154)	Teenah (n = 30)	Dezadeash (n = 208)
0	0.65		3.37
1	0.65		20.67
2	11.69		13.94
3	42.21	6.67	12.02
4	38.96	40.00	31.25
5	5.84	40.00	17.79
6		13.33	0.48
7			0.48

(Squanga). However, there has been little study devoted to the question of spawning areas or migrations.

Limiting Factors

To date, the only documented decline in abundance and/or range of the Squanga Whitefish has been due to direct human disturbance. This occurrence was the poisoning of Hanson Lake by rotenone to prepare the lake for the planting of Rainbow Trout. [An unusual dwarf Lake Whitefish-like form which existed in Dragon Lake, British Columbia, was also exterminated by poisoning to prepare the lake for Rainbow Trout planting (C. C. Lindsey, unpublished data).] Many lakes in the Yukon Territory have now been sampled in an unsuccessful attempt to discover additional populations of Squanga Whitefish (Lindsey et al. 1981) but it is certainly possible that populations exist which are presently undetected. Any lake which is to be considered for fish introductions in British Columbia and Yukon should be carefully sampled to determine the presence of any Squanga Whitefish forms (or other rare or undescribed forms), especially if the lake is to be poisoned prior to the introduction.

Special Significance of the Form

The Squanga Whitefish is known only in Canada. These fishes are rare and the form is probably made up of at least two distinct genetic lineages. These populations are of great importance in the study of evolutionary processes. The Squanga Whitefish may have been in existence for only a short period of time (perhaps as little as 10 000 years) or it may have originated during Pliocene or early Pleistocene times in an ancestral Alsek River watershed (Lindsey and McPhail 1986). The Squanga Whitefish also represents a unique source of genetic material for fish culture. The form may prove to be invaluable as a fish which is able to utilize an exclusively planktivorous diet but which grows to a larger size than many cisco species. Therefore, further loss of Squanga Whitefish populations would thus be unfortunate from a number of points of view.

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Status of the Deepwater Sculpin, *Myoxocephalus thompsoni*, in Canada*

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The Deepwater Sculpin, *Myoxocephalus thompsoni*, is closely related to the Fourhorn Sculpin, *Myoxocephalus quadricornis*, and has been only recently resurrected as a separate species. *Myoxocephalus thompsoni* is recognized as a glacial relict. It remains relatively common in specific lakes within its range but is believed extirpated from Lake Ontario and possibly Lake Erie.

Le Chabot de profondeur, *Myoxocephalus thompsoni*, proche parent du Chaboisseau à quatre cornes, *Myoxocephalus quadricornis*, n'a que récemment acquis le statut d'espèce. *Myoxocephalus thompsoni* est considéré comme une espèce relique de l'époque glaciaire. Il est encore relativement commun dans certains lacs de son aire de répartition, mais on croit qu'il est déraciné, dans le lac Ontario et peut-être dans le lac Érié.

Key Words: Deepwater Sculpin, *Myoxocephalus thompsoni*, rare and endangered fishes, Great Lakes watershed, Cottids

The Deepwater Sculpin, *Myoxocephalus thompsoni*, is the largest of the freshwater sculpins. It is grotesquely-shaped with body and head slender and somewhat elongate (Figure 1). It reaches an average length of 10 cm, but specimens as large as 25 cm total length have been reported. All the fins, except the pelvics, are long and well developed. There are two dorsal fins, one soft-rayed, the other with long spines. Its mottled skin is smooth, with no typical scales but having scattered tubercles or prickles which feel rough to the touch. The lateral line is conspicuously raised and appears chain-like, stretching almost to the caudal fin (see Scott and Crossman 1973).

Distribution

The Deepwater Sculpin has been the subject of several taxonomic and zoogeographic studies. A marine form, *Myoxocephalus quadricornis*, a freshwater form, *Myoxocephalus quadricornis thompsoni*, and various ecological integrades have been described (McAllister 1961; Hubbs and Lagler 1964; McPhail and Lindsay 1970; Dadswell 1972). McAllister et al. (1978) have differentiated *Myoxocephalus quadricornis* from *Myoxocephalus thompsoni* based on morphological characters and consider the two as distinct species. The common name (Deepwater Sculpin), and the

scientific name (*Myoxocephalus thompsoni*) have been adopted by the American Fisheries Society (Robins et al. 1980).

The Deepwater Sculpin found in Canada is somewhat similar to freshwater forms in Europe (Khan and Faber 1973); however little information concerning the taxonomic status of these populations is available. D. E. McAllister (National Museum of Natural Sciences, Ottawa, Ontario, personal communication) considers that the similarities are due to parallel evolution. This report discusses only the populations in North America.

In North America, the Deepwater Sculpin is considered a glacial relict and as presently known is confined entirely to Canadian waters except for Torch Lake, Michigan and the Great Lakes (Dadswell 1972; Scott and Crossman 1973). McAllister and Wells (1980) provided a recent account of the range of this species. They report that its range extends from southwestern Quebec through the Great Lakes and thence northward to southern Manitoba, northern Saskatchewan and finally to the Great Bear — Great Slave lakes area (Figure 2). An isolated population has been discovered in southern Alberta (McAllister and Ward 1972).

*Threatened status (in the Great Lakes watershed) approved and assigned by COSEWIC 7 April 1987.

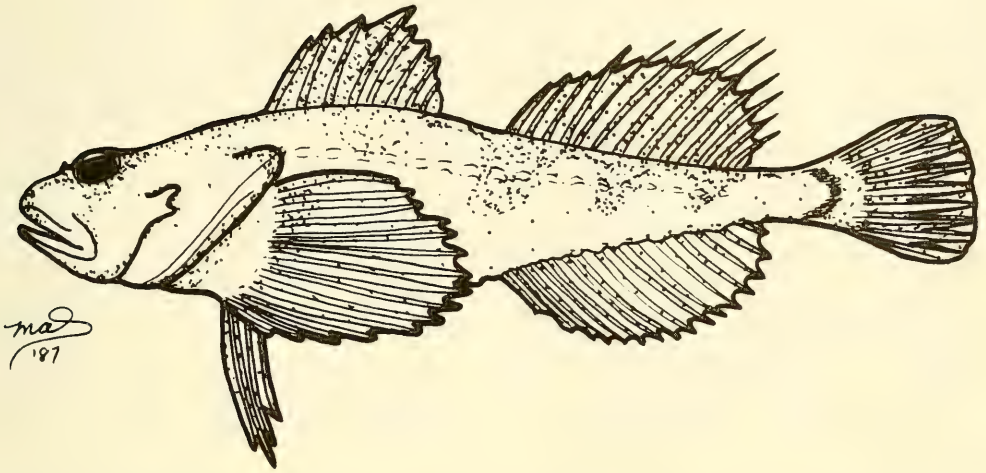


FIGURE 1. Drawing of the Deepwater Sculpin, *Myoxocephalus thompsoni* (Drawing by M. Service, courtesy Department of Fisheries and Oceans).

The apparent discontinuous distribution of this species is attributable in part to the spotty occurrence of lakes with suitable environmental conditions and the necessary connections with postglacial lakes, and in part to the infrequent sampling of its preferred habitat with suitable gear (McAllister and Ward 1972).

Protection

There is no specific protection for this species in law. The fish habitat provisions of the Fisheries Act of Canada provide minimal, general protection.

Population Sizes and Trends

Information on the size and trends of the Deepwater Sculpin populations in many lakes within its range is generally limited to presence-absence data. More extensive information is available for some Great Lakes populations.

Within the Great Lakes the Deepwater Sculpin is believed relatively common in Lake Huron (N. R. Payne, Lake Huron Fisheries Assessment Unit, Ontario Ministry of Natural Resources, Owen Sound, Ontario, personal communication), the U.S. waters of Lake Superior (Anderson and Smith 1971), and in Lake Michigan (Mansfield et al. 1983). It is believed extirpated from Lake Ontario (Scott and Crossman 1973; Gray 1979) and has not been recently collected in Lake Erie despite sampling with appropriate gear (R. McGregor, Lake Erie Fisheries Assessment Unit,

Ontario Ministry of Natural Resources, RR #2 Wheatly, Ontario, personal communication). No recent information is available from the Canadian waters of Lake Superior (W. McCallum, Lake Superior Fisheries Assessment Unit, Ontario Ministry of Natural Resources, Thunder Bay, Ontario, personal communication). Wells (1968) reported that this species was fairly abundant in eastern Lake Superior in the early 1950s. The status of the Deepwater Sculpin in Lake Nipigon is unknown (R. Borecky, Lake Nipigon Fisheries Assessment Unit, Ontario Ministry of Natural Resources, Beardmore, Ontario, personal communication), but selective sampling of deepwater areas planned for the future may provide new information.

The disappearance of Deepwater Sculpin from Lake Ontario was detailed by Christie (1973). Apparently, they were common in Lake Ontario prior to the 1950s, but disappeared some time between the mid 1950s and early 1960s. Netting throughout the 1960s, including three lake wide surveys, yielded only a single specimen (D.E. McAllister, personal communication.).

Scott and Crossman (1973) suggested that the Lake Ontario population may have been extirpated as a result of DDT pollution. Theories of recruitment failure as a result of predation or competition by Alewife (*Alosa pseudoharengus*) populations have also been suggested (Gray 1979).

In Lake Michigan, the Deepwater Sculpin is apparently undergoing a resurgence in numbers



FIGURE 2. Distribution of Deepwater Sculpin, *Myoxocephalus thompsoni*, in Canada: ● Identified populations in smaller lakes; //// Extant population in larger lakes: (1) Lake Erie — Rare, possibly Extirpated; (2) Lake Ontario — Extirpated.

(Mansfield et al. 1983). The Deepwater Sculpin had declined in abundance in the early 1960s as a result of recruitment failure, perhaps stimulated by Alewife predation/competition (Wells 1980) and possibly cannibalization of their own eggs (Wells 1980).

Deepwater Sculpin were reported as locally common in western Lake Superior during the late 1960s (Anderson and Smith 1971). The studies of Anderson and Smith (1971) suggest that this species was common in the Apostle Islands area, comprising approximately 2.8% of the total catch, and were the most common species at depths of 50-59 fathoms (91.5-108 m).

Elsewhere, evidence of the continued well being of this species is provided only by recent collection records. Specimens have been reported from several lakes in northwestern Ontario, an area in which they were previously unknown (G. Gale, Ontario Ministry of Natural Resources, Toronto,

Ontario, personal communication). Atton and Merkowsky (1983) also provided recent collection records from northern Saskatchewan which suggest that this species may be common in some lakes. F. Atton (Fisheries Branch, Saskatchewan Department of Parks and Renewable Resources, Saskatoon, Saskatchewan, personal communication) also cautioned against defining population status or trends without further sampling. McPhail and Lindsay (1970) suggested that this fish may be common in Great Bear lake and possibly other lakes of the Northwest Territories.

Habitat

The Deepwater Sculpin is a bottom dwelling species. In the Great Lakes this species is most abundant at depths greater than 40 fathoms [73m] (Wells 1968; Anderson and Smith 1971; Scott and Crossman 1973). In other lakes, chiefly in the north, this species has been reported from all

depths (McPhail and Lindsay 1970; McAllister and Wells 1980). Dryer (1966) reported collections from Lake Superior which were taken from a depth of 200 fathoms (366 m). Characteristically, the lakes which contain this species are cold and deep.

No clear preference for substrate type has been identified. Jacobs (1953) collected specimens over mud, clay, silt, sand, rock and aquatic vegetation. McPhail and Lindsay (1970) reported this species as invariably associated with a mud bottom.

Spawning sites have not been identified; however, it may be inferred that spawning takes place in deepwater areas.

Larval Deepwater Sculpins are pelagic and are dispersed by currents and upwellings (Mansfield et al. 1983). Other habitat preferences are unknown.

General Biology

Reproductive Capability: Black and Lankester (1981) reported a maximum age of 5 years for this species. Age at maturity was estimated by the same authors at 3 years for females and 2 years for males at 85 mm total length (TL). Maximum lengths of 200-250 mm TL have been reported (Scott and Crossman 1973). In general, maximum size decreases with an increase in latitude.

Jacobs (1953) reported the sex ratio to be 1:1 males to females. Jacobs (1953) also provided egg counts ranging from 165 to 1187 (mean 481) per female.

The precise spawning period of the Deepwater Sculpin and its spawning habitats are unknown. Most evidence of spawning is extrapolated from larval fish collections and examination of adult specimens. Throughout its range, ripe specimens have been collected from August to October (McAllister 1961; McPhail and Lindsay 1970; Black and Lankester 1981). Khan and Faber (1973) suggest that Deepwater Sculpin in the Great Lakes spawn through the winter, spring and early summer months. D. Faber (National Museum of Natural Sciences, Ottawa, Ontario, personal communication) suggests that normal cues which serve to initiate spawning, such as changes in water temperature or photoperiod, may not be appropriate for this species in the depths of the Great Lakes. A resultant attenuation of the spawning period may result. The theory of an extended spawning period is supported by the findings of Mansfield et al. (1983) who report larval deepwater sculpin first appearing in Lake Michigan power plant entrainment records during early February, but the number of larvae did not peak until March and April, with occasional

specimens collected as late as mid-July. Larvae ranged in length from 8.0 to 18.3 mm.

Deepwater Sculpin larvae have been described by Khan and Faber (1973) and Heufelder (1982).

Species Movement: No information has been documented on the occurrence of spawning migrations. McPhail and Lindsay (1970) have suggested that a shift to somewhat shallower waters during the fall may occur. Wells (1968) reporting on Lake Michigan populations concluded that during October, November, February and March, Deepwater Sculpin had no more shallow a distribution than during summer. This may have lead Mansfield et al. (1983) to state that inshore spawning migrations are not likely with spawning occurring at depths greater than 21 m.

Larval Deepwater Sculpin are found dispersed through the entire water column and are often carried to inshore areas by currents and upwelling (Khan and Faber 1973; Mansfield et al. 1983).

Behaviour/Adaptability: Little is known of the behaviour or adaptability of the Deepwater Sculpin. Analysis of stomach contents from adults across their range suggest a benthic feeding habit. Food items included *Pontoporeia*, *Mysis relicta* and chironomid larvae (McAllister 1961; McPhail and Lindsey 1970). Wells (1980) reported egg cannibalism by some juveniles and adults.

This species is believed to be a major prey item of both the Lake Trout (*Salvelinus namaycush*) and Burbot (*Lota lota*) (Scott and Crossman 1973; Day 1983). Moffett (1957) described the food chains of the deepwater fish community in Lake Michigan and considered this species a vital link within the system.

The adaptability of this species is unknown. Whether the species in Lake Ontario suffered from chronic exposure to contaminants or from competition from introduced species or indeed some other combination of factors remains unresolved.

Limiting Factors

The historical limiting factor for Deepwater Sculpin in Canada is the availability of deep cold water lakes which have had the necessary post-glacial links.

This species may be susceptible to chronic trace contaminant exposure, pesticide exposure or to shifts in species composition in the deepwater community.

Special Significance of the Species

This species is of little commercial or sport interest. It is the only member of the genus

Myoxocephalus found in the freshwaters of Canada, but is only one of several species contained within the family Cottidae. Other freshwater Cottids in Canada are common.

This species is of special interest to members of the scientific community concerned with Canadian post-glacial dispersal and zoogeography (Scott and Crossman 1973).

Its role in the conversion and transport of energy to higher trophic levels within the deepwater ecosystem has been discussed (Moffett 1958; Day 1983), however the real impact of losing this species from the deepwater community has not been tested. Nevertheless, it was in lakes Ontario and Erie, and is elsewhere an important component of the diet of Lake Trout and Burbot (Christie 1973; Day 1983).

Evaluation

The Deepwater Sculpin remains relatively common throughout much of its range. Although very little current data exists concerning population trends or reproductive potential, all indications are that there are many extant populations of the Deepwater Sculpin.

However it is probably extirpated from Lake Ontario and possibly Lake Erie. Causative factors have not been identified.

On a regional basis the Great Lakes populations may be considered threatened as the species has been extirpated in Lake Ontario and the Lake Erie population must be regarded as at least threatened, if not extirpated, pending further specific sampling programs. Elsewhere in Canada the species does not appear to be in jeopardy but additional information is required to determine population sizes and trends.

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Le Statut du Suceur cuivré, *Moxostoma hubbsi*, au Canada*

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Le Suceur cuivré, *Moxostoma hubbsi*, est exclusif aux eaux canadiennes. Sa répartition géographique est extrêmement limitée; il ne se retrouve que dans quelques rivières des terres basses du sud-ouest du Québec. Très fécond et longévif, il est, malgré tout, rare dans toute son aire de répartition. Le résultat de fouilles archéologiques laisse supposer qu'il a déjà été plus abondant. La pollution des eaux ainsi que la détérioration de son habitat semblent être les principaux facteurs responsables de son déclin. Le Suceur cuivré est doté d'un appareil pharyngien hautement spécialisé pour le broyage des coquilles et son alimentation est essentiellement constituée de Mollusques. Cette espèce n'est soumise à aucune protection légale particulière, si ce n'est l'interdiction de l'utiliser comme appât à la pêche sportive. Compte tenu de sa répartition géographique extrêmement restreinte, de la faible densité de ses populations et de l'état de détérioration de plusieurs des cours d'eau où il a été recensé, le Suceur cuivré devrait avoir le statut d'espèce menacée. Ce statut pourrait être révisé une fois que le programme d'assainissement de ces cours d'eau aura été complété.

The Copper Redhorse, *Moxostoma hubbsi*, is found exclusively in Canadian waters. Its geographic distribution is very restricted since it is found only in a few rivers in the lowlands of southwestern Québec. Despite its great fecundity and longevity, it is rare throughout its range. However, archaeological studies suggest the species was more abundant in the past. Water pollution and habitat degradation seem to be the main factors leading to its decline. The Copper Redhorse has a highly specialized pharyngeal apparatus for crushing shells and its diet consists essentially of molluscs. This species is not protected by any specific legislation, except that its use as a bait for sport fishing is prohibited. Because of its very restricted geographic distribution, its low population densities, and the poor state of many of the waterways in which it occurs, the Copper Redhorse should be considered a threatened species. This status could be revised when current programs to restore these waterways are completed.

Mots clefs: Suceur cuivré, *Moxostoma hubbsi*, suceurs, espèces rares et menacées, poissons du Québec, Catostomidés.

Le Suceur cuivré, *Moxostoma hubbsi*, (Figure 1) est, avec une demi-douzaine d'autres tout au plus, une espèce de poisson exclusive au Canada et probablement la seule qui soit exclusive au Québec. Sa reconnaissance officielle remonte à 1942, date à laquelle il fut décrit pour la première fois par M. Vianney Legendre, ichthyologiste québécois de renom (voir Legendre 1942).

Il appartient à la famille des Catostomidés ou au groupe des poissons qui ont la bouche en forme de suçoir et qui sont communément appelés, bien qu'improprement, "Carpes". Les Catostomidés sont des poissons de taille relativement grande qui mesurent, suivant les espèces, entre 30 et 70 cm et pèsent entre 0,5 et 5 kg à l'âge adulte. Dans la région de Montréal, cette famille inclut sept

espèces, deux Menuniers, caractérisés par de petites écailles, et cinq Suceurs, tous avec de grandes écailles.

Les structures morphologiques les plus caractéristiques des Catostomidés sont sans contredit celles de leur appareil pharyngien qui est analogue à l'appareil de broyage ou de mastication des diverses autres espèces animales. Il est disposé au fond de la bouche, en forme de couronne, autour de l'ouverture de l'oesophage. Il comprend deux arcs osseux de forme conique et recourbée, soudés par la base. Chacun porte sur sa face antérieure une série de dents disposées en une seule rangée (Figure 2). Les traits distinctifs de cet appareil concernent principalement la forme des arcs ainsi que le nombre et la forme des dents. En général, plus les

*Threatened status approved and assigned by COSEWIC 7 April 1987.

Espèce désignée comme menacée par le CSEMOC, le 7 avril 1987.

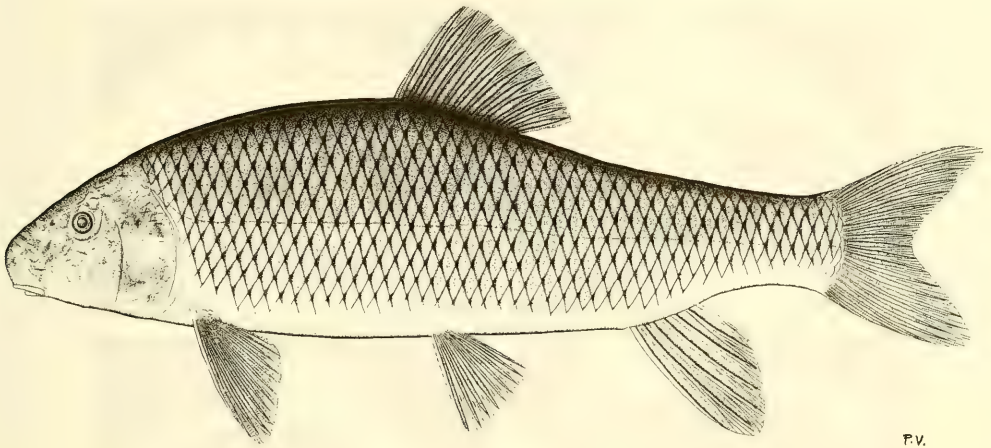


FIGURE 1. Le Suceur cuivré (*Moxostoma hubbsi*). Courtoisie de P. Vecsei.

dents sont nombreuses, moins elles sont volumineuses et plus elles sont minces et aplaties en dents de peigne; par contre, moins elles sont nombreuses, plus elles sont grosses et plus elles sont cylindriques et semblables à de grosses molaires.

On peut reconnaître le Suceur cuivré parmi les autres suceurs par ses caractéristiques pharyngiennes. Chez le Suceur cuivré, l'appareil pharyngien (Figure 2) est exceptionnellement robuste et bien développé; la largeur des arcs, à la base, correspond au tiers de leur hauteur. Les dents, au nombre de 18 à 21 sur chacun des arcs, sont très volumineuses à la base mais de plus en plus petites en approchant du sommet. En plus des structures précédentes, l'appareil pharyngien du Suceur cuivré comprend une pièce osseuse, en forme de butoir, rattachée au basioccipital. Celle-ci fait face aux deux arcs et s'emboîte exactement avec les dents. L'ensemble du système s'avère très efficace pour le broyage des coquilles de Mollusques dont cette espèce, comme nous le verrons plus loin, se nourrit abondamment.

On peut utiliser les particularités de l'appareil pharyngien pour différencier le Suceur cuivré du Suceur jaune, *Moxostoma valenciennesi*, en vérifiant, à l'aide de l'ongle ou d'un objet mince quelconque, s'il existe une discontinuité dans la structure osseuse de la paroi postérieure de la chambre branchiale. En effet, tandis que, chez le Suceur cuivré, on perçoit, sous la peau, un espace longitudinal d'environ un millimètre de largeur dans la cloison formée, d'une part, par le cleitrum près de l'extérieur, et, d'autre part, par l'arc pharyngien un peu plus en profondeur, chez le

Suceur jaune la cloison est, au contraire, parfaitement lisse et ne comporte aucune faille.†

Répartition

Le Suceur cuivré, *Moxostoma hubbsi*, une espèce dont la reconnaissance officielle remonte à 1942 (Legendre 1942) est endémique au Canada. Son aire de répartition est restreinte au sud-ouest du Québec (Figure 3). Tous les spécimens recensés proviennent de cours d'eau de la plaine du Saint-Laurent, soit les rivières Richelieu, Yamaska, Noire, des Milles Isles, Maskinongé et la partie du fleuve Saint-Laurent depuis l'ouest de l'île de Montréal jusqu'à l'extrémité est du lac Saint-Pierre (Figure 4). Tous les efforts réalisés à ce jour pour capturer le Suceur cuivré en dehors des limites de sa répartition actuelle ont été vains (Legendre 1964; Jenkins 1970; Mongeau et al. 1986).

Le Suceur cuivré est probablement l'intérieur des limites de sa répartition actuelle. Il serait le résultat d'un processus local de l'évolution qui aurait eu lieu au Québec depuis le retrait des glaciers, il y a moins de 10 000 ans (Mongeau et al. 1980).

† Pour faciliter la distinction des différentes espèces de Catostomidae un tableau d'identification a été préparé. Il peut être obtenu en écrivant à Monsieur Mongeau à l'adresse suivante: Service de l'aménagement et de l'exploitation de la faune, Ministère du Loisir, de la Chasse et de la Pêche, 6255, 13e avenue (Rosemont), Montréal, QC H1X 3E6.

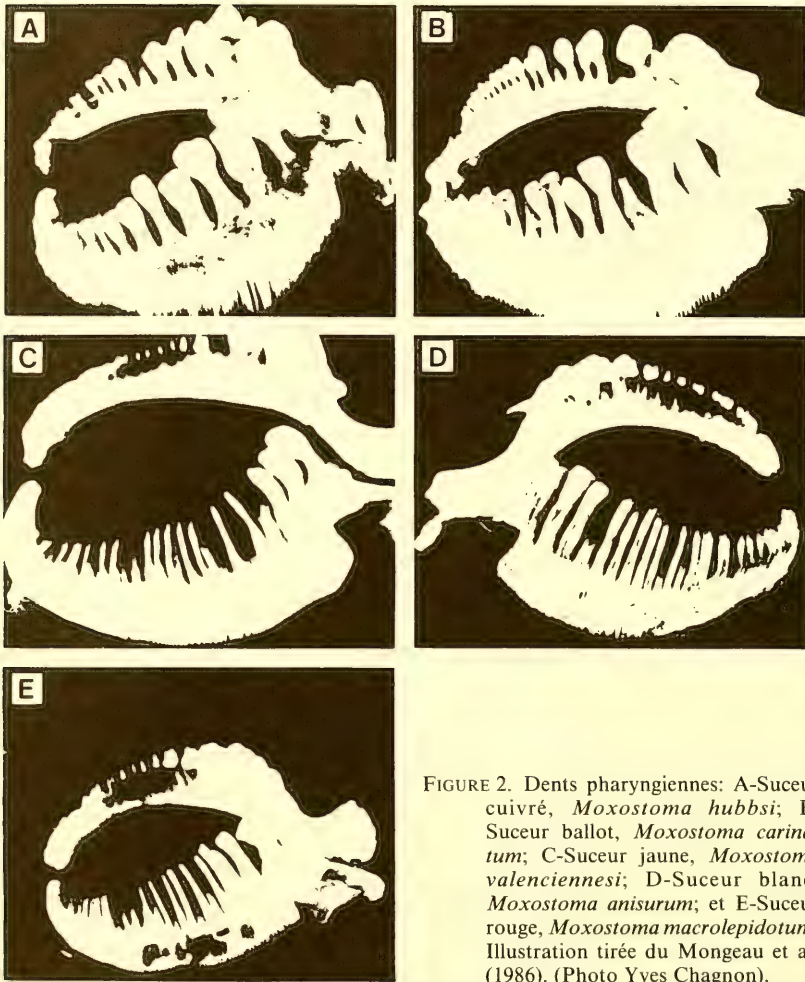


FIGURE 2. Dents pharyngiennes: A-Suceur cuivré, *Moxostoma hubbsi*; B-Suceur ballot, *Moxostoma carinatum*; C-Suceur jaune, *Moxostoma valenciennesi*; D-Suceur blanc, *Moxostoma anisurum*; et E-Suceur rouge, *Moxostoma macrolepidotum*. Illustration tirée du Mongeau et al. (1986). (Photo Yves Chagnon).

Protection

Le Suceur cuivré n'est soumis à aucune protection légale particulière, si ce n'est l'interdiction de l'utiliser comme appât à la pêche sportive. Cependant, la loi sur les Pêcheries du Canada, le Règlement de pêche du Québec qui en découle, la Loi québécoise sur la conservation et la mise en valeur de la faune ainsi que la Loi québécoise sur la qualité de l'environnement, particulièrement en ce qui a trait aux travaux d'aménagement soumis à des études d'impact, assurent, à l'espèce et à son habitat, une certaine protection. Ces lois sont par contre insuffisantes pour en garantir le maintien.

Nombre et tendances démographique

Le Suceur cuivré est rare dans toute son aire de répartition. De 1942 à 1985, seulement 248

spécimens ont été officiellement recensés (Mongeau et al. 1986). Cette espèce ne représente que 3% de l'ensemble des Suceurs recensés par Mongeau (1963-1985) dans la région de Montréal (Massé 1977; Mongeau et al. 1986), les autres espèces étant le Suceur jaune, le Suceur ballot, *Moxostoma carinatum*, le Suceur blanc, *Moxostoma anisurum*, et le Suceur rouge, *Moxostoma macrolepidotum*.

L'état des populations varie d'un cours d'eau à l'autre. Celle de la rivière Richelieu semble être la plus importante. Les travaux d'inventaire effectués entre 1963 et 1973 montrent que le Suceur cuivré, quoique rare, est présent dans l'ensemble du secteur à l'aval du bassin de Chambly. Par ailleurs, quelques géniteurs des deux sexes, appartenant à différents groupes d'âge et de taille, ont été



FIGURE 3. Répartition canadienne du Suceur cuivré (*Moxostoma hubbsi*). Courtoisie de D. E. McAllister, Musée National des Sciences Naturelles.

capturés en 1984 et 1985, sur deux sites de fraye (Mongeau et al. 1986). Les travaux d'inventaire effectués entre 1963 et 1969, dans les rivières Yamaska et Noire, avaient révélé la présence de ce Suceur en amont du barrage de Saint-Hyacinthe. Cependant, en dépit d'efforts légers mais orientés en 1977, 1978, 1985, et 1987, aucun spécimen n'y a été capturé depuis 1969. De nouvelles vérifications s'imposent pour savoir si l'espèce a survécu (Mongeau et al. 1986). Des 13 spécimens recensés dans toute l'étendue de la rivière des Mille Îles, 12 ont été capturés entre 1971 et 1973, et un en 1980. En juin 1986, un effort de pêche limité (2 jours de pêche électrique et 20 jours-filets) n'a pas permis de capturer de Suceur cuivré. L'état actuel de cette population reste à préciser (Mongeau et al. 1986).

Dans le fleuve Saint-Laurent, entre l'ouest de l'île de Montréal et l'extrémité est du lac Saint-Pierre, 14 individus ont été capturés entre 1942 et 1973. En dépit d'un effort de pêche intensif, aucun spécimen n'a été recensé autour de l'île de Montréal, depuis les quatre capturés en 1942. Dans la rivière Maskinongé, un tributaire du versant nord du fleuve Saint-Laurent, un seul spécimen a été signalé, près de son embouchure dans le lac Saint-Pierre; il a été trouvé parmi les victimes d'une importante mortalité de poissons en 1971. Dans ces deux derniers cours d'eau, les résultats des inventaires intensifs indiquent que l'espèce y est sans doute très rare (Mongeau et al. 1986).

Des fouilles archéologiques récentes (Ostéothèque de Montréal Inc. 1984; Courtemanche et al.

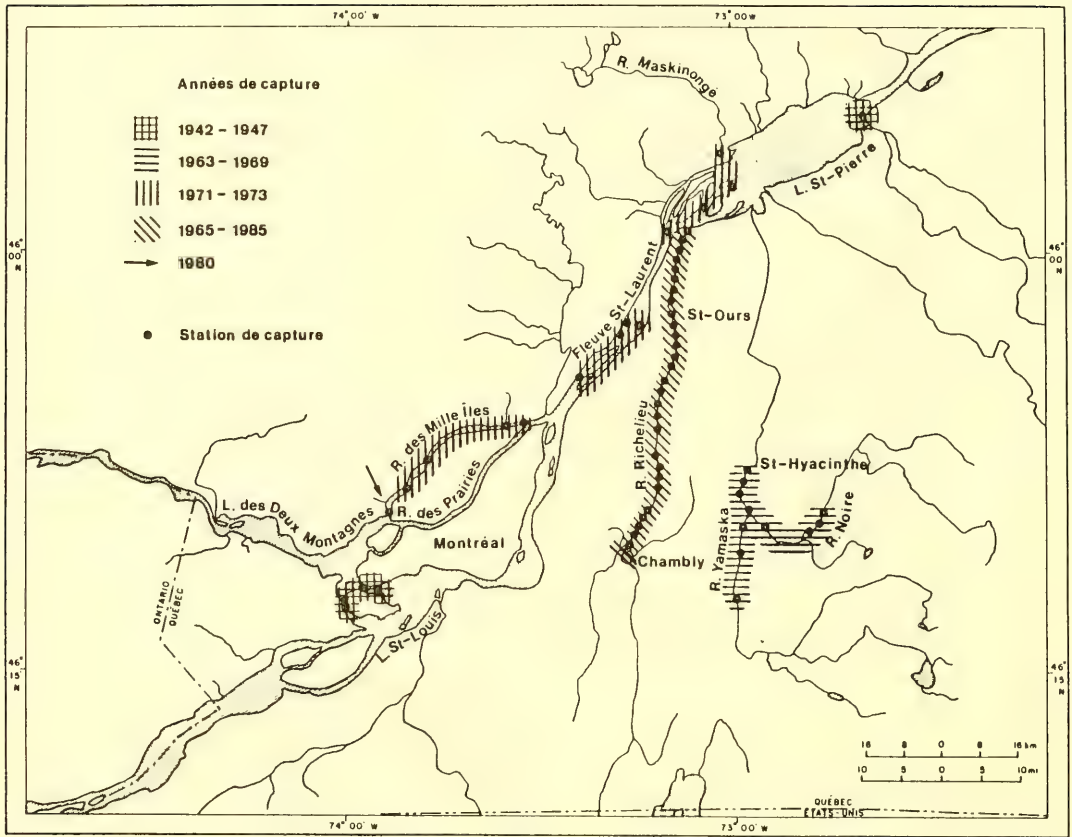


FIGURE 4. Répartition du Suceur cuivré (*Moxostoma hubbsi*) dans le sud-ouest du Québec. Tous les spécimens ont été capturés dans les rivières Richelieu (N = 178), Yamaska et Noire (N = 42), des Mille Îles (N = 13), Maskinongé (N = 1) et dans le fleuve Saint-Laurent, depuis l'amont de l'île de Montréal jusqu'à l'extrémité est du lac Saint-Pierre (N=14).

1985) montrent que, à diverses époques de l'histoire et de la préhistoire, le Suceur cuivré était probablement plus abondant qu'il ne l'est présentement. En effet, l'analyse ostéologique des dépôts du site Mandeville (antérieur au début de la colonisation), sur la rivière Richelieu, et celui de la Place Royale (1802-1838), à Montréal, a confirmé la présence du Suceur cuivré et a permis d'en estimer l'abondance relative. La proportion de cette espèce par rapport à l'ensemble des cinq espèces de Suceurs était, dans les échantillons recueillis, de trois à quatre fois supérieure à celle qui a été observée lors des inventaires régionaux (Mongeau et al. 1986).

Habitat

Selon Mongeau et al. (1986), le Suceur cuivré n'est présent que dans quelques rivières de la

plaine, d'importance moyenne, aux berges abruptes, uniformément profondes (4-7 m). La température estivale de l'eau y dépasse 23°C. Les tronçons fréquentés sont caractérisés par un courant modéré et un fond dur, généralement constitué de glaise, de sable ou de gravier. Ces tronçons sont entrecoupés de rapides, où l'espèce trouve les conditions favorables à sa reproduction. Elle est absente des secteurs peu profonds et recouverts d'une épaisse végétation ou de ceux dont les eaux sont les plus polluées et turbides.

Biologie générale

Jusqu'ici, la biologie de ce poisson n'a été que sommairement étudiée. Selon Mongeau et al. (1986), il peut vivre une vingtaine d'années, atteindre environ 70 cm et peser plus de 5 kg. La croissance est semblable chez les deux sexes. Les

tailles et poids moyens des 72 géniteurs capturés sur les frayères de la rivière Richelieu se situent aux environs de 62 cm (de 53 à 69 cm) et de 3,6 kg (de 2 à 5,5 kg). La maturité sexuelle est atteinte vers l'âge de dix ans par les deux sexes. La durée de la vie reproductive peut atteindre une douzaine d'années. La fécondité est remarquable. Des cinq espèces de Suceurs capturées au bassin de Chambly, c'est la plus féconde. La production d'une femelle de 2 kg est de l'ordre de 32 750 oeufs et elle peut atteindre 112 000 oeufs dans le cas des plus gros spécimens. La fraye a lieu durant les deux dernières semaines de juin, lorsque la température de l'eau atteint environ 20°C.

Deux frayères ont été identifiées, toutes deux dans la rivière Richelieu: l'une à l'aval du barrage de Saint-Ours et l'autre à l'aval du barrage de Chambly (Mongeau et al. 1986). Les sites utilisés ont généralement une profondeur inférieure à deux mètres, un fond pierreux et un courant de moins de deux mètres par seconde. Suite à la capture d'un géniteur, Massé et al. (1981) font état d'une frayère potentielle au rapide du Grand Moulin sur la rivière des Mille Îles. Les chenaux de Dorion et de Saint-Anne-de-Bellevue, entre le lac des Deux Montagnes et le lac Saint-Louis, pourraient également être des sites de fraye (Jenkins 1970). Selon Mongeau et al. (1986), d'autres sites présentent un bon potentiel: ce sont les rapides de Lachine, le bief d'aval de la centrale hydro-électrique de la rivière des Prairies et le rapide de Terrebonne sur la rivière des Mille Îles.

Les principales espèces associées au Suceur cuivré ont été identifiées à l'aide du coefficient probabiliste de Krylov (1968), en utilisant les captures enregistrées lors de l'inventaire systématique de la rivière Richelieu et du bassin des rivières Yamaska et Noire. Dans ces deux milieux, les espèces le plus étroitement associées au Suceur cuivré sont: la Carpe, *Cyprinus carpio*, le Suceur blanc ainsi que le Suceur ballot, une espèce qui est également rare (Mongeau et al. 1986).

Le Suceur cuivré est doté d'un appareil pharyngien hautement spécialisé pour le broyage. Sa diète se compose, dans un proportion supérieure à 90%, de Mollusques et semble relativement uniforme dans toute son aire de répartition (Mongeau et al. 1986). La comparaison de son alimentation avec celle des autres espèces de Suceurs capturées dans le bassin de Chambly, montre qu'il est celui qui manifeste la plus grande spécialisation dans l'utilisation des ressources alimentaires. Dans son aire de répartition, d'autres espèces de poissons se nourrissent de Mollusques, mais aucune de façon aussi exclusive. Apparem-

ment, le Suceur cuivré tire avantage de cette diète puisque son taux de croissance dépasse celui de la plupart des autres espèces de suceurs de l'Amérique du Nord, bien qu'il habite des eaux relativement froides pour ce genre (Mongeau et al. 1986).

Facteur limitatifs

Le Suceur cuivré habite des cours d'eau qui irriguent la région la plus peuplée du Québec; le déboisement généralisé, la mise en culture des terres et l'urbanisation y ont transformé l'environnement. Il en est résulté, dans les rivières, un accroissement de la superficie des herbiers, à l'avantage de certaines espèces de poissons, et une réduction correspondante des espaces libres, qu'utilisent les Suceurs. L'implantation et la multiplication de nouvelles espèces telles que la Carpe ont été favorisées. Celle-ci, par sa fécondité exceptionnelle, sa rusticité, ses habitudes fouis-seuses et son régime alimentaire omnivore, s'impose comme un compétiteur potentiel du Suceur cuivré. La mise en place de barrages a pu contribuer à la disparition de certaines populations par la dégradation de la qualité du milieu de vie, la réduction de la superficie des habitats disponibles ou la destruction de frayères.

La dégénérescence des cours d'eau par la pollution, l'accroissement de la turbidité et l'envasement des fonds sont généralement considérés comme les principales causes de réduction des populations de Suceurs (Jenkins 1970; Trautman 1981; Parker et McKee 1984; Pearson et Krumholz 1984). La pollution reliée au développement urbain, agricole et industriel représente une menace pour le Suceur cuivré (Scott et Crossman 1974). Le problème ne se présente pas avec la même acuité partout. Les eaux de la rivière Richelieu, l'émissaire du lac Champlain, sont affectées par un certain degré de contamination (Goulet et Laliberté 1982a, b) mais la qualité de l'eau, en regard des exigences de la faune aquatique en générale, y est bonne (Bérubé 1983). Le débit des autres cours d'eau habités par ce poisson et la qualité de leur eau dépendent d'avantage de la fréquence et de l'abondance des précipitations. Les mortalités massives y sont relativement fréquentes. En période estivale, les rivières des Mille Îles et Yamaska subissent régulièrement des étiages sévères, généralement accompagnés d'une dégradation du milieu aquatique. Dans les secteurs le plus pollués du bassin de la Yamaska, tels que l'aval de la ville de St-Hyacinthe, aucun Suceur cuivré n'a été capturé lors de l'inventaire de 1969. Il semble être celui qui tolère le moins la pollution,

parmi les Suceurs qui fréquentent les mêmes eaux (Mongeau et al 1986). McAllister et al. (1985) font état du danger que constituent les pluies acides pour les Mollusques, la principale ressource alimentaire de ce poisson.

Importance particulière de l'espèce

L'intérêt et l'importance du Suceur cuivré sont d'ordre scientifique et écologique. Cette espèce endémique du sud-ouest du Québec est un exemple unique d'une répartition géographique extrêmement limitée. Le degré de spécialisation de son appareil pharyngien représente, pour bon nombre de spécialistes, une somme évolutive (Jenkins 1970; Eastman 1977; Mongeau et al. 1986). Les Suceurs en général, dont le Suceur cuivré, par leur habitude de fréquenter les profondeurs, mettent à profit de vastes espaces et des ressources alimentaires qui sont inutilisées par la grande majorité des autres espèces.

Ce poisson est sans grande valeur économique; il n'est à peu près pas recherché par les pêcheurs sportifs ou commerciaux. Cependant, au lac Saint-Louis, les Suceurs sont en demande à deux occasions: lors de certaines fêtes ethniques, comme plats rituels et, comme appât, pour la pêche commerciale de l'Esturgeon jaune (*Acipenser fulvescens*).

Évaluation

À l'heure actuelle, il semble que seule la rivière Richelieu et, peut-être, la rivière des Mille Îles abritent des populations suffisamment abondantes pour qu'elles soient décelables. Ces deux cours d'eau drainent des secteurs de forte concentration urbaine, industrielle et agricole. Même dans ces rivières, le Suceur cuivré est rare. À la lumière des quelques informations obtenues lors de fouilles archéologiques, il apparaît qu'il était probablement plus abondant avant que ne s'amorce le développement de la région. Présentement, en raison de son extrême rareté, de l'exigüité de son aire de répartition et de l'état de détérioration de la plupart des cours d'eau où il a été répertorié, ce poisson est très vulnérable à une dégradation temporaire ou permanente de la qualité de son milieu de vie, comme cela pourrait se produire à la suite d'une période d'anoxie, d'un déversement majeur de substances toxiques ou de la destruction de zones de fraye. Nous estimons que le Suceur cuivré devrait être considéré comme une espèce menacée tant et aussi longtemps que le programme d'assainissement des cours d'eau fréquentés ne sera pas complété.

Remerciements

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Updated Status of the River Redhorse, *Moxostoma carinatum*, in Canada*

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Parker, B. J. 1988. Updated status of the River Redhorse, *Moxostoma carinatum*, in Canada. Canadian Field-Naturalist 102(1): 140-146.

The River Redhorse, *Moxostoma carinatum*, is rare in Canada. Reproducing populations of this large member of the sucker family have been located in four river systems in eastern Ontario and southwestern Quebec. Small populations have been reported from the Mississippi River, a tributary to the Ottawa River in Ontario, and the Richelieu and Yamaska River basins in Quebec. Specimens are also taken occasionally from the Ottawa River near Ottawa, and the St. Lawrence River near Montreal. This species reaches its northeastern range limit in Canada and Canadian populations are geographically separate from those in the U.S.A. Populations may be declining, possibly because of removal of adults and habitat alteration. The River Redhorse is not specifically protected in Canada, although general protection is afforded by the habitat sections of the Fisheries Act. In April, 1983, COSEWIC assigned and approved a status of rare for the River Redhorse. Information collected in 1986 by the Ontario Ministry of Natural Resources and the author suggests that the status of this species should be retained as rare.

Le Suceur ballot, *Moxostoma carinatum*, est rare au Canada; des populations génitrices de ce grand membre à la famille suceur ne sont présentes que dans quatre réseaux fluviaux à l'est de l'Ontario et le sud-ouest du Québec. On a dit que les populations petites existent dans la rivière Mississippi, un tributaire de la rivière Ottawa en Ontario et dans les bassins des rivières Richelieu et Yamaska au Québec. De temps en temps on trouve des spécimens dans la rivière Ottawa près de Ottawa et la rivière St. Laurent près de Montréal. L'espèce atteint la limite nord-est de son aire de répartition au Canada; les populations canadiennes sont géographiquement séparées des populations américaines. Il se peut que les populations soient en déclin, peut-être à cause de la capture d'adultes et de modifications de l'habitat. Au Canada, le Suceur ballot ne fait pas l'objet d'une protection spéciale mais une protection générale lui est accordée en vertu des articles sur la protection de l'habitat de la Loi sur les pêcheries. En avril 1983, le CSEMDC lui a donné le statut d'espèce rare. Le Ministère des richesses naturelles de l'Ontario et l'auteur ont recueilli des renseignements en 1986 qui insinuent que le statut de cette espèce soit garder comme rare.

Key Words: River Redhorse, *Moxostoma carinatum*, Catostomidae, suckers, rare fishes.

The River Redhorse, *Moxostoma carinatum*, is a moderately larger Catostomid of the genus *Moxostoma*. These suckers (commonly referred to as redhorse suckers) are larger than the suckers of the *Catostomus* genus and are more laterally compressed, although they are otherwise superficially similar. One of the main differences between the genera is the swim bladder which has three chambers in the redhorse in place of two. The redhorse species are often difficult to distinguish (see Scott and Crossman 1973) and little information is available on their biology and ecology (for a more detailed account of the groups see Jenkins 1970).

Moxostoma carinatum (Figure 1) is a medium sized redhorse about 30 to 45 cm in length and weighing up to 4 kg (Scott and Crossman 1973).

The body is deep and laterally compressed; the back and dorsal surface are brown to lime-green in colour with paler sides shading to white ventrally. The River Redhorse has a very limited Canadian distribution and is of little economic importance due to its restricted range and population size.

Distribution

The River Redhorse is found in central and eastern North America (Jenkins 1980). In Canada this species is found only in southern Ontario and southwestern Quebec in the Great Lakes basin (Figure 2). The range of the River Redhorse in Canada may be decreasing; currently extant populations are located only in eastern Ontario and southwestern Québec (Figure 3). However, this species is difficult to distinguish from other

*Rare status approved and assigned by COSEWIC 6 April 1983. Updated report reviewed and approved 7 April 1987 with no change in status.

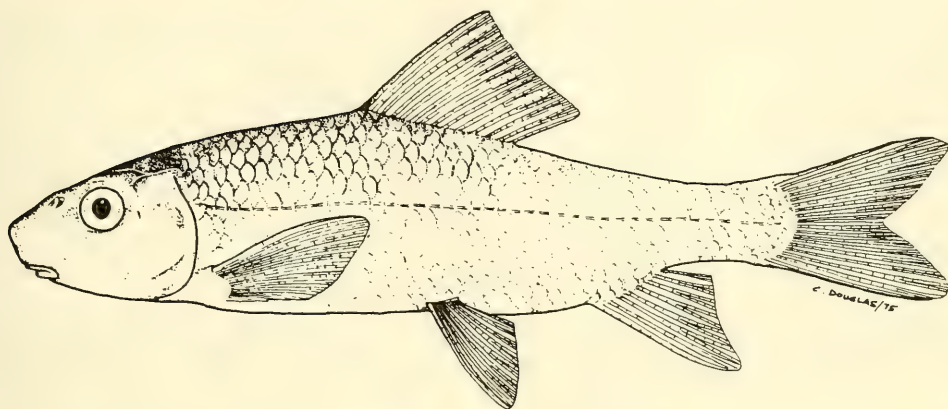


FIGURE 1. River Redhorse, *Moxostoma carinatum*. Courtesy D. E. McAllister, National Museum of Natural Sciences; drawing by C. Douglas.

redhorse species, and its actual distribution cannot easily be determined. The closest populations of River Redhorse in the United States are believed to be in Kentucky and Missouri approximately 1 300 kilometers southwest of populations in Canada.

Protection

International: The River Redhorse is listed as endangered in Kansas (Platt 1974) and Ohio (Ohio Department of Natural Resources 1976), threatened in Florida (Gilbert 1978), and rare in Missouri. It is believed to have been extirpated from Michigan, much of Iowa, Illinois, Indiana, and Pennsylvania (Jenkins 1970).

National: The River Redhorse is not specifically protected in Canada, although fish habitat sections of the Fisheries Act of Canada do afford general protection. In April 1983, the Committee on the Status of Endangered Wildlife in Canada (COSEWIC) assigned and approved a status of rare for the River Redhorse (Parker and McKee 1984).

Population Sizes and Trends

River Redhorse specimens have been taken from widely separated locations within the Great Lakes basin suggesting that its distribution may have been more broad in the past. Today reproducing populations are known only from the Richelieu and Yamaska River basins in southern Quebec and the Mississippi River in eastern Ontario. Adult River Redhorse were recently identified by the Ontario Ministry of Natural Resources from the lower Mississippi River near its confluence with

the Ottawa River, and I suggest that other populations may exist in the Ottawa River.

Other reports of the River Redhorse in southern Ontario place the species in the Ausable River in the 1930s [Royal Ontario Museum (ROM) Record Number 28250]. The continued existence of this population is in doubt because of a lack of suitable habitat. Other species of redhorse suckers are present in the Ausable River but there are no plans to determine the distribution, population size or species present (M. Maillot, Ontario Ministry of Natural Resources, Wingham, Ontario; G. Duckworth, Ontario Ministry of Natural Resources, Chatham, Ontario; personal communications). D. E. McAllister (National Museum of Natural Sciences, Ottawa, Ontario; personal communication) caught no River Redhorse in a 1985 survey of the Ausable River. The River Redhorse had been reported from Fairchild Creek in the Grand River system [National Museums of Canada (NMC) 77-0212] but review of the specimens by E. Kott (Wilfred Laurier University, Waterloo, Ontario; personal communication) confirms that this report was in error.

The River Redhorse has been reported from a very few locations on the Ottawa River, near Ottawa [one specimen] (McAllister and Coad 1974) and from several locations in the Montreal region (Mongeau et al. 1974; Mongeau and Masse 1976; Masse 1977). No estimates of population size for the Ottawa River or the St. Lawrence River system have been developed. The paucity of specimens reported does suggest that this species is very rare in these large river systems.



FIGURE 2. Canadian distribution of the River Redhorse, *Moxostoma carinatum*.

A current estimate of the population size of River Redhorse in the Yamaska and Richelieu River basins is not available. An evaluation was provided by Masse (1977) who reported that the River Redhorse contributed 2.41% of the total number of suckers captured in surveys between 1963 and 1973 in the Richelieu and Yamaska River basins.

Based on the location of capture sites and percent composition data provided by Masse (1977) and Mongeau (1979) the center of the River Redhorse population in the Richelieu River is believed situated in the Chambly Basin and extends downstream to the dam at Saint-Ours, a distance of about 40 km. In the Yamaska River system this species is captured most frequently upstream of Saint-Hyacinthe, and in the lower sections of the Noire River (see Figure 3). In the

Richelieu River this species constitutes less than 1% of the sucker population, in the Yamaska the River Redhorse constitutes 4% of the sucker population (Masse 1977). Trends in the population size are not known.

An estimate of the population size of River Redhorse in the Mississippi River was made by Parker and McKee (1980) who suggest that it constitutes about 5% of the redhorse populations at capture sites. The population appears to be centered in a 55 km section of river from Galetta to Almonte (see Figure 3). The stability of this population is unknown, however, observations between 1977 and 1984 suggest that the number of River Redhorse is declining.

No estimates of recruitment or mortality are available. Incidental capture by sports fishing on the Mississippi River and sports and commercial

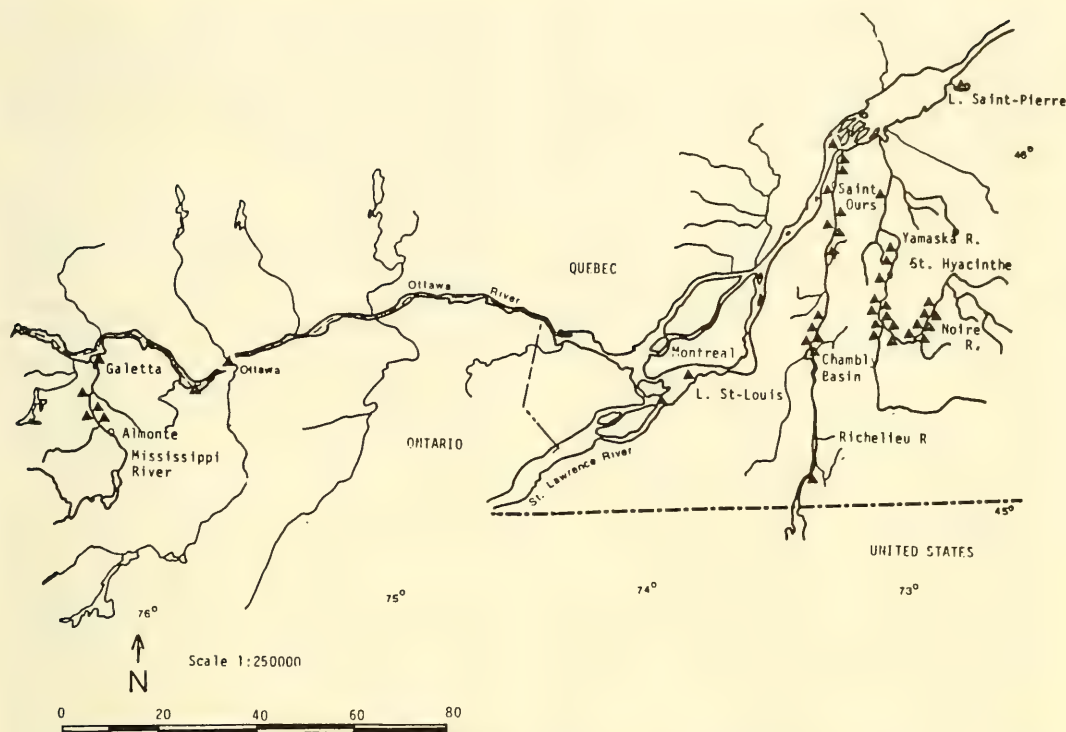


FIGURE 3. Distribution of River Redhorse, *Moxostoma carinatum*, in the Ottawa and St. Lawrence River Basins.
 ▲ Capture Sites

fishing on the Richelieu River may increase the rate of mortality beyond what may be normally anticipated.

Habitat

The River Redhorse occurs in rivers and riverine lakes within its Canadian range. A review of capture localities suggests several similarities in habitat including a propensity for fast flowing waters in the main flow of moderate to large rivers, river sections which attain a mean July temperature greater than 20°C and an affinity for watersheds dominated by limestone or shale bedrock.

Substrates at capture sites are typically formed of stones, rubble and bedrock which are free of heavy siltation. This species is captured infrequently in sluggish environments which have an abundant growth of macrophytes or soft substrates. Jenkins (1970) also noted that this species is rarely captured in deeper waters of slow flows which have silt and sand bottoms.

The River Redhorse appears to be relatively inflexible in its habitat requirements. Very few specimens have been collected in environments which do not fit the above description. It is very possible that these combined factors limit the distribution and population size of River Redhorse.

The River Redhorse is believed to spawn over rock and cobble substrates in fast flowing shallow waters. In 1984 I located a possible spawning site in the Mississippi River. Observations suggest that the area is unique within this section of the Mississippi River because of its substrate and water depth characteristics. The substrate was similar to others on the river except for a greater percentage of gravel and small stone. Additionally, water depths were relatively shallow, normally ranging from 0.30 to 0.80 m. Hackney et al. (1967) also observed spawning River Redhorse over gravel shoals in flowing waters from 0.15 to 1 m deep. Information on similar habitats in the Richelieu and Yamaska rivers is not available.

The River Redhorse spawns in the spring but spawning migrations have not been documented. Many of the other redhorse species do exhibit spawning migrations (Jenkins 1970) and this species is not believed the exception. Nursery areas and overwintering areas have not been identified for this species.

General Biology

No comprehensive studies of the life history of this species in Canada exist. However, much of the available information has been presented by McAllister et al. (1985).

In Canada the River Redhorse spawns in late May or early June. Recently, spent specimens were collected in late June from the Mississippi River at water temperatures of 20 to 22°C; females taken at Galetta in May had large eggs. Spawning may occur at slightly cooler temperatures. These data are supported by Jenkins' (1970) findings of tuberculate males in Quebec in early June.

Spawning has not been observed for Canadian populations of River Redhorse; however, my observations in the Mississippi River in 1984 suggest that this species may construct spawning redds. Shallow swept depressions 10 to 15 cm deep and 50 to 75 cm long were noted at the base of a shallow rapids in which River Redhorse were observed. Examination of these reddlike features failed to confirm their formation or use by this species. Hackney et al. (1967) also reported that River Redhorse excavate spawning redds.

No estimates of fecundity are available from Canadian populations but fecundity is reported to range from 6078 to 23 075 for fish 45 to 65 cm long (Hackney et al. 1967). Eggs are non-adhesive and relatively large, 3.7 to 4.4 mm in diameter. The incubation period is quite short, 3 to 4 days at 22°C (Fuiman 1982).

Age at maturity is not known, however, a specimen from the Mississippi River aged at 7 years was mature (NMC 79-0174). Very few specimens under 5 years have been collected in Canada. This species is relatively large, the largest specimen reported from Ontario was 617 mm long and weighed approximately 2814 g. No length-weight data was obtained for Quebec populations. Maximum age is approximately 14 years (Parker and McKee 1980).

River Redhorse feed extensively on benthic organisms but my observations indicate that they will take an introduced bait. Examination of gut contents from 10 Ontario specimens showed that fish 100 to 150 mm long fed primarily on chironomid larvae and pupae, while fish 200 to

250 mm long also ate crustaceans, trichopterans and coleopterans. Larger River Redhorse also consumed molluscs, insect larvae and crayfish.

The large adult size of River Redhorse and rapid growth rate of young-of-the-year exclude this species from the diet of many predators.

Limiting Factors

The River Redhorse may have the most restrictive habitat requirements of any redhorse sucker found in Canada. In the future, its inability to adapt to increased siltation and perhaps pollution in general may restrict the distribution of this species even further.

In late 1985 a proposal to establish a small hydro electric facility on the Mississippi River was developed by private interests and the Ontario Ministry of Energy. This development, if completed, could effectively block much of the Mississippi River River Redhorse population from moving upstream to the only identified spawning area. Unless a mitigative strategy is formulated which insures that River Redhorse can access spawning sites it is very likely this population would disappear if the development proceeded.

Possibly the factor which may prove to be most limiting is the general lack of awareness of this species by the scientific community. Our ability to effectively manage the River Redhorse is greatly impaired by our lack of knowledge in the areas of life history, population structure and distribution. Few field biologists have been able to identify the River Redhorse. The remarks of Peden and Hughes (1984) for another rare species are equally applicable to the River Redhorse situation: "this lack of recognition could facilitate the species decline if society or the scientific community are not aware of the species uniqueness as part of Canada's natural fauna".

Special Significance of the Species

Canadian populations are disjointed and at the northern limit of the range. The species has some importance to sport and commercial fishermen. As one of the few mollusc eating fishes in Ontario, the River Redhorse plays an important role in the aquatic ecosystem.

Evaluation

The River Redhorse has a restricted distribution in Canada and breeding populations are known only from four river systems. This species is especially susceptible to anthropogenic degradation because of its special environmental requirements and because of its restricted

distribution. It is in a vulnerable position because its main centres of population are downstream of industrial, municipal and agricultural contaminant sources. However, of a more insidious and long-term nature may be the destruction of habitat by siltation and impoundment of flowing waters.

In the short term the outlook for the continued existence of this species in the Mississippi River is jeopardized and threatened by a proposed hydro electric development. Water use practices in the two Quebec watersheds of concern are unlikely to change quickly and River Redhorse populations in these rivers may not be immediately threatened. However, it is also evident that habitat and water quality conditions may change quickly on these rivers because of the intensity of development along their margins.

The identification of several River Redhorse in the lower Mississippi River, below barriers to the Ottawa River is encouraging and suggests that other populations may be present outside of the Mississippi River.

In the long term a more informed management system could provide a better understanding of this species and permit the continued existence of the River Redhorse in Canada.

Pending more complete studies of River Redhorse populations in Canada it is recommended that the River Redhorse be continued to be considered a rare species.

Acknowledgments

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Updated Status of the Silver Shiner, *Notropis photogenis*, in Canada*

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Baldwin, M. E. 1988. Updated status of the Silver Shiner, *Notropis photogenis*, in Canada. Canadian Field-Naturalist 102(1): 147-157.

The Silver Shiner, *Notropis photogenis*, is rare in Canada. In the United States it occurs in Lake Erie tributaries and the Ohio, Tennessee, and Cumberland River watersheds. In Canada it occurs in the Grand and Thames River watersheds and Bronte Creek in southwestern Ontario. Canadian populations may be long separated from American populations. Canadian populations are locally abundant and appear to have increased prior to or during the 1970s and 1980s. Some American populations have decreased in this century, with some fluctuations. The Silver Shiner inhabits the deeper pools of medium to large streams with moderate to high gradients; spawning habitat is unknown. Water quality does not seem to be a problem now in Ontario. Canadian habitat quality has probably declined in the past; current trends may be positive or negative depending on location. Growth appears to be rapid and maximum length reported in Ontario is 10.85 cm. Most Silver Shiners mature during their second summer. It is a schooling species, primarily a surface feeder, but not highly specialized in its diet. Limiting factors are not yet known, but stream gradient may be affecting distribution. It is recommended that the Silver Shiner continue to be classified as a rare species in Canada. There is high potential for maintenance of the Canadian populations.

Le Méné-miroir, *Notropis photogenis*, est rare au Canada. Aux États-Unis, on le rencontre dans les tributaires du lac Érié et dans les bassins des rivières Ohio, Tennessee et Cumberland. Au Canada, il fréquente les bassins des rivières Thames et Grand et le ruisseau Bronte, dans le sud-ouest de l'Ontario. Il se peut que les populations canadiennes soient séparées depuis longtemps des populations américaines. Elles sont abondantes localement et semblent avoir augmenté avant ou pendant les années 1970 et 1980. Certaines populations américaines ont diminué au cours du siècle avec quelques fluctuations. Le Méné-miroir habite les plans d'eau profonds de cours d'eau moyens et grands, dont l'inclinaison va de modérée à élevée; on ne connaît pas les lieux de fraie. La qualité de l'eau ne semble pas constituer un problème pour le moment en Ontario. La qualité de l'habitat au Canada s'est probablement dégradée dans le passé. Les tendances actuelles peuvent être positives ou négatives à différents endroits. La croissance semble être rapide; la longueur maximale signalée en Ontario est de 10,85 cm. La plupart des individus atteignent la maturité au cours de leur deuxième été. Ce poisson vit en banc et se nourrit surtout en surface, mais n'a pas un régime alimentaire très spécialisé. On ne connaît pas encore les facteurs limitatifs, mais il se pourrait que la pente du cours d'eau influe sur la distribution de l'espèce. On recommande que le Méné-miroir soit continué classer comme espèce rare au Canada. Il y a des fortes chances qu'on puisse assurer le maintien des populations canadiennes.

Key Words: Silver Shiner, *Notropis photogenis*, cyprinids, minnows, southwestern Ontario, rare fishes.

The Silver Shiner, *Notropis photogenis*, is a slender, elongate minnow (Figure 1) which is silvery in colour with a dark lateral stripe. These fish are small, the adults are not greater than 13 cm long and they have a somewhat triangular head with large eyes and mouth.

The species closely resembles the Rosyface Shiner, *Notropis rubellus*, and Emerald Shiner, *Notropis atherinoides*, and is often misidentified with the former (Parker and McKee 1984).

They can be distinguished from the Rosyface Shiner by the position of the dorsal fin which is almost directly above the pelvic fin in the Silver Shiner (Scott and Crossman 1973).

Distribution

The Silver Shiner is endemic to North America, and has a fairly wide distribution (Figure 2) in the east-central United States (Gilbert 1980). It is found throughout most of the Ohio River basin in West Virginia, western New York and Pennsylvania, Ohio, Indiana, and Kentucky, although it is absent in the western lowlands section of the Ohio River. This species also occurs in the upper Cumberland and Tennessee River watersheds in the Appalachian Mountains. In the Great Lakes basin the Silver Shiner is found in tributaries of Lake Erie in Ohio, Indiana, and Michigan. Trautman (1981, p. 323) found that there had been

*Rare status originally assigned by COSEWIC April 1983. No change in status April 1987.

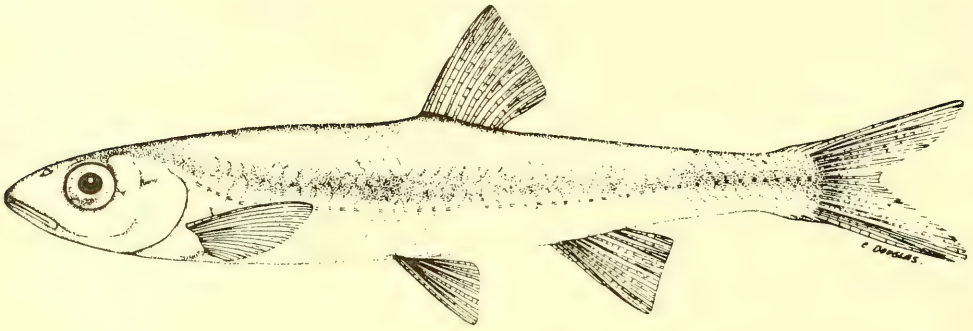


FIGURE 1. Drawing of the Silver Shiner, *Notropis photogenis*, in North America (NMC 71-854; courtesy D. E. McAllister, National Museum of Natural Sciences; drawing by C. Douglas).

little change in the distribution of Silver Shiners in the Ohio River watershed in Ohio between 1854 and 1980 although it "must have been present . . . in the Ohio River before that stream was impounded and when it was less turbid and less polluted".

The first report of Silver Shiners in Canada was of captures made in 1971 (Gruchy et al. 1973). However, older collections have since been found in the Royal Ontario Museum Records. Specimens previously misidentified as Rosyface Shiners had been taken in the Grand and Thames River systems previous to this (Nith River: 1949; Grand, Conestogo and Nith Rivers: 1966; South Thames River: 1936; North Thames River: 1946). It is now known to occur in the Lake Erie, Lake St. Clair, and Lake Ontario drainages of Ontario (Figure 3). In the Grand River watershed of Ontario (Figure 4), the Silver Shiner occurs in the main stream from seven km south of Elora, Wellington County (43°37'25"N, 80°26'45"W) to Brantford, Brant County (43°06'40"N, 80°14'55"W). It also occurs in the lower stretches of two major tributaries, the Conestogo and Nith Rivers, and near the mouths of four smaller tributaries, Schneider, Whitemans, Rogers and McKenzie creeks.

In the Lake St. Clair drainage, the Silver Shiner population is centered near the city of London, Middlesex County, in the Thames River watershed (Figure 5). All specimens were collected within approximately a 40 km radius of the city centre (42°59'22"N, 81°14'57"W): from the North Thames, Medway, South Thames, and Middle Thames Rivers, and the main branch.

The discovery of Silver Shiners in Bronte Creek, a tributary of Lake Ontario (Figure 3), represents

the most recent extension of the species' known distribution in Canada. Silver Shiners were captured at Zimmerman, Regional Municipality of Halton (43°26'N, 79°50'W) in July 1983 by E. Kott, Wilfred Laurier University.

There is no direct evidence for a reproductively isolated population of Silver Shiners in Canada, but a number of factors suggest that Canadian populations have long been separated from American populations. Gruchy et al. (1973) and Parker and McKee (1980) argued that the first Canadian Silver Shiner populations recognized in 1971 were not likely the result of a recent introduction or colonization from the United States. The existence of specimens from the 1930s and 1940s confirms their arguments. For the same reasons, continued contact between American and Canadian populations is unlikely. Gruchy et al. (1973) noted that Silver Shiners are unlikely to have crossed Lake Erie because they have never been reported from the lake (Van Meter and Trautman 1970) nor are they abundant in the tributaries to the lake, both of which provide unsuitable habitat for the species. It is also unlikely that Silver Shiners were introduced into Ontario by sport fishermen (being 130 km from the nearest American populations) since the fish survive only for short periods in bait buckets (Parker and McKee 1980).

Recent colonizations in the Grand, Thames and Bronte Creek watersheds are unlikely as there are no direct connections between the watersheds. Tributaries of both the Thames River and Bronte Creek do however, arise near tributaries of the Grand River. These areas are far from the range of the species and seem improbable as recent

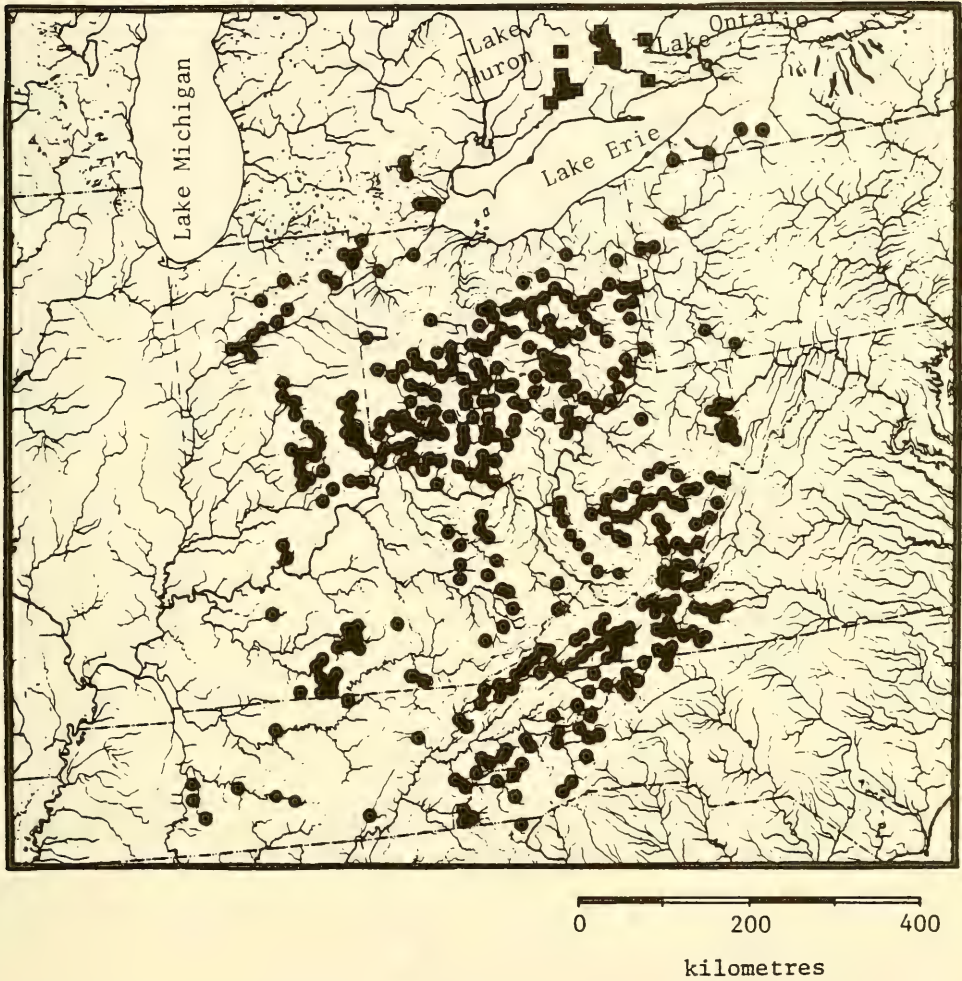


FIGURE 2. Distribution of the Silver Shiner, *Notropis photogenis*, [modified from Gilbert (1980); new Canadian records are indicated as ■].

colonization routes (Baldwin 1983). There are also a number of dams within the Grand and Thames River portions of the species' distribution which appear to be impassable, at least to upstream movement, preventing recent colonization from either the lakes or within the rivers (Baldwin 1983).

Protection

No specific protection for the Silver Shiner now exists in Canada, although the fish habitat section of the Fisheries Act does afford general protection. The species was assigned a rare status by the Committee on the Status of Endangered Wildlife

in Canada (COSEWIC) in April 1983 (Parker and McKee 1984).

Population Size and Trends

The Silver Shiner was found to be locally abundant in the Grand and Thames River watersheds by Parker and McKee (1980). Their 1979 catches averaged 37 Silver Shiners per 100 m². As expected for a vigorous-swimming, schooling species (*see* General Biology), sample densities were not constant, and they found several sampling stations in the two watersheds which seemed to provide suitable habitat, but had few or



FIGURE 3. Collection records of *Notropis photogenis* in Ontario: ▲ National Museums of Canada; ■ Royal Ontario Museum; ◆ Ontario Ministry of Natural Resources; ● Beak (Parker and McKee 1980); △ Baldwin (1983); □ Wilfred Laurier University Museum; ◇ Grand River Conservation Authority.

no specimens. I also found variation in numbers among samples, and captured young-of-the-year more frequently than adults (Baldwin 1983). However, Figures 4 and 5 indicate that on a larger scale the species occurs almost continuously throughout each river section within its range. Silver Shiners were rare in, or absent from, smaller tributary streams and slow-flowing sections of the main rivers.

The increase in captures of the species since 1971 suggest an increase in numbers prior to or during the 1970s or early 1980s. The new locations for Silver Shiners found in Ontario since 1971 are not simply the result of surveys of new areas. The Ontario Ministry of Natural Resources, the Grand River Conservation Authority, Parker and McKee (1980), and I (Baldwin 1983) sampled extensively within the Grand and Thames River watersheds; the results included new captures at previously surveyed locations.

There are no data to evaluate population levels or trends in Bronte Creek.

Former low population levels (along with misidentification) may at least partially account for the fact that Silver Shiners were not detected in Ontario until recently (Gruchy et al. 1973). Population fluctuations have occurred elsewhere. Gruchy et al. (1973) noted that Silver Shiners were not taken in Michigan between 1942 and 1952, but appeared again in surveys after 1952. The Silver Shiner decreased considerably in numbers in many Ohio localities between 1920 and 1950 (Trautman 1981). It is generally uncommon to rare in Lake Erie tributaries (Gilbert 1980) and was apparently decreasing in numbers in those tributaries in 1970 (Van Meter and Trautman 1970). In Michigan the Silver Shiner was considered to have changed from rare status to threatened (Miller 1972). However, Trautman (1981) reported Silver Shiner captures during the 1970s, from several Lake Erie

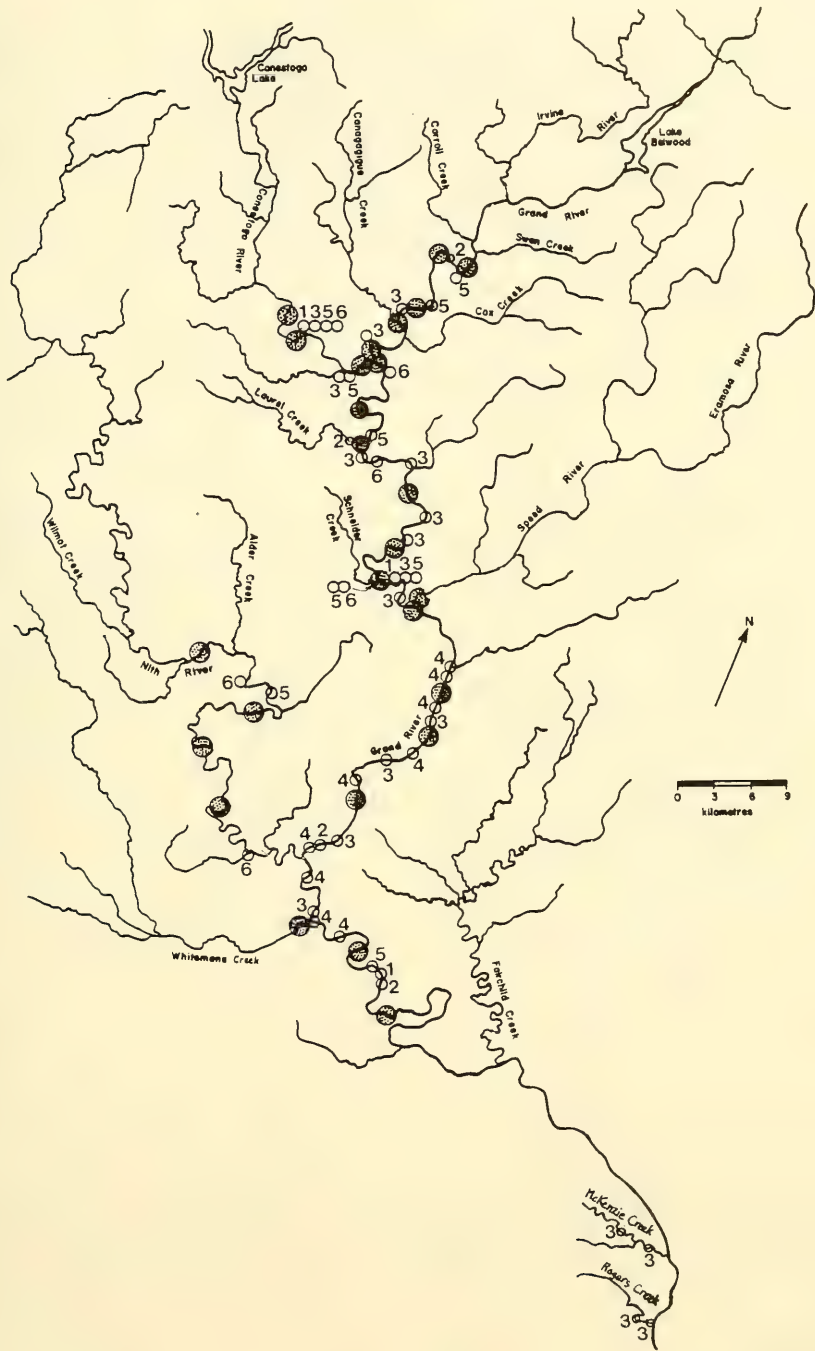


FIGURE 4. Distribution of Silver Shiner, *Notropis photogenis*, in the Grand River watershed of Ontario (modified from Baldwin 1983). Symbols: ⊙ Baldwin (1983); ○ Collections by: (1) National Museum of Natural Sciences; (2) Royal Ontario Museum; (3) Ontario Ministry of Natural Resources; (4) Grand River Conservation Authority; (5) Parker and McKee (1980); (6) Wilfred Laurier University.

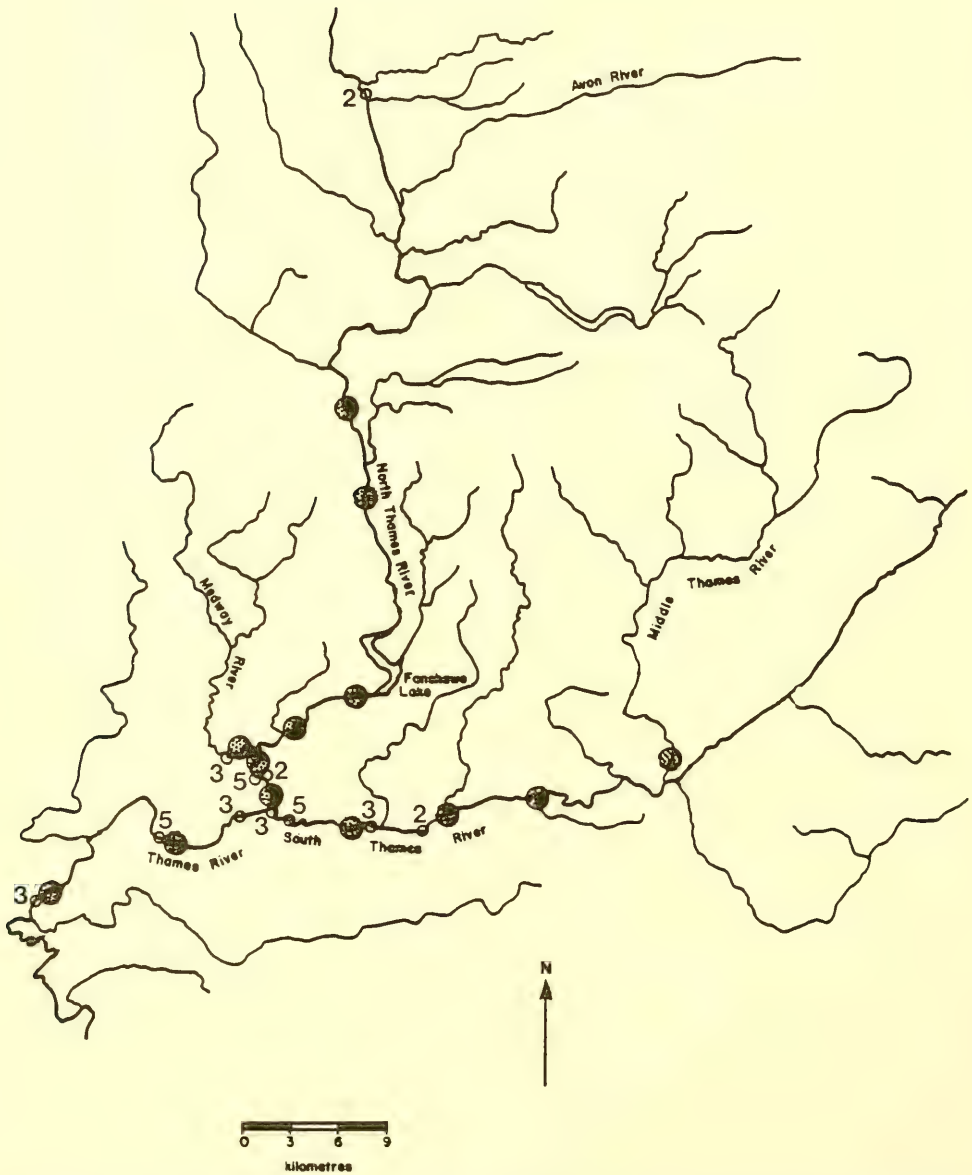


FIGURE 5. Distribution of Silver Shiner, *Notropis photogenis*, in the Thames River watershed of Ontario (modified from Baldwin 1983). Symbols: ● Baldwin (1983); ○ Collections by: (2) Royal Ontario Museum; (3) Ontario Ministry of Natural Resources; (5) Parker and McKee (1980).

tributaries in northeastern Ohio where it had never been captured before despite earlier collecting.

The data thus appear to indicate a currently or recently increasing Silver Shiner population in

Ontario. There are insufficient data to indicate whether its distribution has also changed, or whether all documented range extensions are due simply to increasing populations or better surveys.

TABLE 1. Standard lengths (cm) of Silver Shiners by age category and date of capture.

Reference	Young-of-the-Year (YOY) or Juveniles	Adults
Trautman (1981)	3.8–6.1 (YOY, October)	5.1–7.6 (1 year) 6.9–11.0 (adult)
Gruchy et al. (1973)	3.3–5.5 (Juvenile, July–August)	5.7–10.9 (adult, July–August)
Parker and McKee (1980)	3.5–5.9 (YOY, August–September)	5.5–7.7 (1+, August–September) 8.7–9.8 (2+, August–September) 8.8 (3+, August–September)
Baldwin (1983)	1.7–2.5 (YOY, June) 2.6–5.8 (YOY, July–August) 4.2–7.1 (YOY, October–November)	3.9–10.7 (adult)

Habitat

Information on Silver Shiner habitat comes from descriptions of capture sites by Trautman (1981), Gruchy et al. (1973), and Parker and McKee (1980), and from a quantitative study of habitat use on a micro-geographic scale by Silver Shiners at seven study sites in the Grand and Thames River watersheds (Baldwin 1983).

In Ohio the Silver Shiner was abundant in moderate to large-sized streams with moderate to high gradients (Trautman 1981). Most rivers and streams inhabited by the species in Ontario fit this description. Stream widths at capture sites of Parker and McKee (1980) ranged from 5 to 100 m, but only two sites had widths less than 30 m. I captured Silver Shiners in streams with widths of approximately 6 to 200 m (Baldwin 1983). Parker and McKee (1980) found that average gradient was 1.4 m/km over the species' Grand River range, 1.4 m/km in the Nith River, 1.9 m/km in the Conestogo River, and 0.5 to 1.4 m/km in the Thames River.

Alternating pools and riffles characterized most sites where Parker and McKee (1980) captured Silver Shiners, and large numbers were also taken in turbulent waters below dams. All specimens were caught in depths ranging between 20 and 100 cm; deeper waters were not sampled. Gruchy et al. (1973) found Silver Shiners in deep (75–100 cm) riffles and flowing pools with moderate to fast currents. Trautman (1981) found them most abundant in deep swift riffles and the faster currents of pools below the riffles. I also found both adult and young-of-the-year Silver Shiners inhabiting deeper water (Baldwin 1983, sites up to approximately 110 cm deep were sampled). Of 21 habitat variables measured, the

best predictor of adult Silver Shiner presence in particular was deep water (Baldwin 1983). Silver Shiners were pool-dwellers: I almost never captured young-of-the-year in riffle habitats, and adults rarely. Unlike the previous authors, I found that current speed was unimportant to adult Silver Shiners, and young-of-the-year were captured in the slower parts of my study sites.

Trautman (1981) and Gruchy et al. (1973) stated that this species usually occurs over gravel to boulder bottoms. Parker and McKee (1980) found Silver Shiners mainly over pebble and cobble bottoms, but they considered substrate unimportant. However, I found that adult Silver Shiners occurred more often over sand, mud, and clay than larger-particle substrates (Baldwin 1983).

Trautman (1981) observed that this species avoids rooted aquatic plants. In Ontario, I usually captured Silver Shiners in areas without submerged vegetation (Baldwin 1983), and Parker and McKee (1980) found no apparent correlation between plant abundance and catch per unit effort of Silver Shiners.

Silver Shiners were captured in water temperatures of 20 to 23.5°C in late summer 1979 (Parker and McKee 1980), and 17.6 to 27.1°C in July and August 1981 (Baldwin 1983). I found that Silver Shiner presence was unrelated to water temperature, except in spring 1982 when adult Silver Shiners occurred in the warmer sections of study sites.

Trautman (1981: p. 323) found that Silver Shiners were most abundant in streams "which had relatively clear waters throughout most of the year". They inhabit the least turbid Lake Erie tributaries (Van Meter and Trautman 1970). However, Ontario data are mixed: the four capture

sites of Gruchy et al. (1973) had cloudy or muddy water; captures by Parker and McKee (1980) were made in clear water with low levels of turbidity; I captured Silver Shiners in clear to cloudy waters (turbidity 3–38 JTU) but found no relationship between the presence of Silver Shiners and turbidity (Baldwin 1983). Other variables associated with water quality — water colour, dissolved oxygen, pH, and conductivity, also seemed unrelated to Silver Shiner presence or absence (Baldwin 1983). Dissolved oxygen levels at capture sites were 8.5 to 13 mg/l in late summer 1979 (Parker and McKee 1980), and 7.0 to 15.2 mg/l in 1981 and 1982 (Baldwin 1983).

Data are limited, but they suggest that night, winter, and spring flood habitat use by Silver Shiners differ from the descriptions above (Baldwin 1983). Silver Shiners were captured in slower currents at night; in deeper pools in November 1981; and along the edges of flooded rivers and in a floodplain pond. Spawning habitat has not been observed in Ontario. In the United States Silver Shiners spawn on riffles (Trautman 1981) and possibly sometimes over chub (*Nocomis* sp.) nests (Stauffer et al. 1979).

Within its Grand and Thames River ranges, Silver Shiner distribution is quite widespread (see Population Size and Trends). Thus suitable habitat would appear to be quite widespread also. There are too few data as yet to define critical habitat such as spawning, early nursery, or overwintering areas or, therefore, trends in the quality and quantity of such critical habitat.

At a general level, the sections of the Grand and Thames River watersheds inhabited by the Silver Shiner have variable but not high water quality. The surrounding areas are largely agricultural and most of the land has been cleared of forest. London, Kitchener, Waterloo, Cambridge, Brantford, and several smaller urban centers are located on these rivers. Following heavy precipitation, levels of suspended solids can increase considerably due to erosion of the intensively farmed soils and other point sources in the region. Wong and Clark (1976) found wide diurnal fluctuations in dissolved oxygen concentrations in southern Ontario streams. The intensive use of these watersheds has existed for some time, so that continued use might be expected to be contributing to a slow deterioration of Silver Shiner habitat. However, some localized improvements have occurred in water quality. For example, dissolved oxygen and biological oxygen demand levels showed considerable improvement between 1963 and 1974 in London following

improved sewage treatment (City of London, unpublished data). Physical habitat changes may result locally from dam construction or channelization of rivers, or less drastically from land use changes. Thus the net habitat change may be positive or negative. The apparent recent Silver Shiner population increases (see Population Size and Trends) suggest the former, although climatic amelioration cannot be excluded as a cause.

In Ohio, Trautman (1981: p. 323) found that "During the 1920 to 50 period the species decreased markedly in numbers in many localities, especially in those portions where turbidity and siltation had increased greatly." He suggested that the species' absence from some rivers was due to turbidity, pollution or impoundments. The apparent lack of effect of water quality on Ontario Silver Shiners may simply be the result of water quality here being within their tolerable range.

Spawning, spring floods, and winter are times when Silver Shiner populations might be particularly susceptible. Good overwintering habitat would be expected to be important to a species at the northern edge of its range. If Silver Shiners simply retreat to flooded river margins during high water, flood shelter habitat is likely less critical. Some flooding is at least an annual occurrence within the Ontario distribution.

Watercourses are publicly owned, but the great majority of riparian lands within the Silver Shiner's range are privately owned. Protection of habitat seems currently adequate. It can continue to be provided by protection or improvement of water quality, and by assessment, and restriction if necessary, of dam construction, channelization, or other undertakings which would create unsuitable habitat.

General Biology

Little information has been published on the age and growth of Silver Shiners, and the scale method of age determination has not been validated for this species (Parker and McKee 1980). Table 1 shows standard lengths (SL) reported for different age groups of Silver Shiners. Parker and McKee (1980) also weighed their fish: young-of-the-year were 0.7 to 2.5 g (preserved weight), age 1+ fish were 2.1 to 4.9 g, 2+ fish 6.7 to 12.5 g, and one 3+ fish was 9.1 g. Although age categories and dates of capture varied among sources, the data suggest that growth is rapid, particularly during the first year, and that growth is similar in Ontario and Ohio. Parker and McKee (1980) examined only one age 3+ specimen, suggesting that most individuals have a maximum age of three winters.

From July to November I captured young-of-the-year much more frequently than older fish (Baldwin 1983). There are no data on sex ratios in any populations.

Few investigations of reproduction in Silver Shiners have been documented. Most Ontario Silver Shiners mature during their second summer (Parker and McKee 1980). One-quarter of specimens less than 5.5 cm long (SL) had maturing gonads. All specimens longer than 6 cm (SL) were mature. These observations suggest that a few Silver Shiners may spawn at age one but most spawn at age two. Spawning has never been observed in Ontario. Based on captures of ripe and then spent specimens, the spawning period was relatively short (on the order of two weeks at any one site [Baldwin 1983]) in late May or June. Spent adults were first captured on 24 June 1980 (Parker and McKee 1980), 4 June 1981, and 17 May 1982 (Baldwin 1983). Average or maximum daily water temperatures on these dates were 18.1 to 23.5°C. Trautman (1981) gave a later spawning date, June or early July, for Silver Shiners in Ohio.

These data indicate that Silver Shiner populations in the Grand and Thames River watersheds are reproducing, but do not indicate reproductive rate. Populations appear to be increasing or to have recently increased (*see* Population Size and Trends), suggesting that reproduction has sometimes more than replaced mortality.

Silver Shiners may move to spawn (Parker and McKee 1980). Captures of young-of-the-year Silver Shiners or ripe or spent adults in relatively small rivers or upstream locations, and immediately below dams, also indicated that there may be some upstream movement to spawn (Baldwin 1983). November 1981 sampling showed most Silver Shiners (along with most other fish) concentrated in many fewer sites than during the summer (Baldwin 1983), suggesting winter concentrations. These concentration areas, if they exist, have no special current protection.

Silver Shiners normally occur in schools (Trautman 1981). Parker and McKee (1980) found that most Ontario schools were composed of individuals of all length classes. However I found some differences in habitat use by adults and young-of-the-year (Baldwin 1983), suggesting some separation of age classes.

Gut content analysis by Parker and McKee (1980) indicated that the Silver Shiner is primarily a surface feeder. Insects comprised more than 90% of the volume of identifiable gut contents. Adult Diptera were present in three-quarters of the specimens examined and accounted, on average,

for more than half of total identifiable volume. The presence of large volumes of immature aquatic insects in many specimens indicated that benthic organisms are also important in the diet. Smaller quantities of nematodes, microcrustaceans, hydrachnids, and filamentous algae were found. There was considerable variation in gut contents among specimens, indicating that the Silver Shiner is an opportunistic feeder. Gruchy et al. (1973) examined the stomachs of nine specimens from the Grand River and found the diet to be composed primarily of adult and larval insects. Trautman (1981) reported that Silver Shiners may jump into the air to capture flying insects. I observed both mid-water and surface feeding (Baldwin 1983).

Silver Shiners are not highly specialized feeders, but they may be characterized as surface feeders. There is some habitat specialization (*see* Habitat); the degree of spawning site specialization is unknown.

Silver Shiners are tolerant of some degree of human disturbance, since they survive and have perhaps recently increased in abundance in the agricultural and urban Grand and Thames River watersheds. Past distribution and population decreases in the United States have however been related to human activities (*see* Habitat). The rate of response of the species to habitat change is unknown, although its short life span and early maturity suggest that relatively rapid population changes are possible.

Limiting Factors

There are insufficient data to identify limiting factors for the Silver Shiner, but several may be suggested. Climatic conditions may be important, particularly because the Canadian populations are at the northern edge of the species' range. In fact, if a favourable climate contributed to the assumed recent population increase of Silver Shiners, then a worsening climate could threaten these populations. Weather could be especially critical in determining winter survival and spawning success.

Habitat loss, environmental contamination, or other aspects of human disturbance are possible factors, and turbidity, pollution, or impoundments may have been responsible for population declines in Ohio (*see* Habitat). Water quality in Ontario is currently within the species' tolerance limits, but how close conditions in Ontario are to those limits is unknown. There are a number of dams now within the Silver Shiner's range, at least some of which appear to be impassable (Baldwin 1983). Each new impoundment would create some unsuitable habitat and restrict movement. Habitat loss could also result from channelization.

Stream gradient appeared to limit the distribution of the Silver Shiner in the Grand River watershed (Parker and McKee 1980). Over the range of this species in the Grand River, the average gradient was 1.4 m/km. An abrupt drop in average gradient to less than 0.3 m/km, in downstream sections beginning immediately below Brantford, corresponded with the downstream limit, in the main channel, of Silver Shiners. An increase in gradient to 5.7 m/km through the Elora Gorge appeared to impose an upstream limit to its range.

There is no evidence to suggest that species competition or predation is limiting, but both are possible factors. Silver Shiners and Rosyface Shiners, a species with similar habits, were associated, but may not be competing for food (Baldwin 1983). A Smallmouth Bass, *Micropterus dolomieu*, was observed seizing a large Silver Shiner in the Grand River, and Rock Bass, *Ambloplites rupestris*, were suggested as possible predators by Parker and McKee (1980).

Parasites are unlikely to be limiting. Silver Shiner specimens collected in Ontario showed no external evidence of parasitic infestation (Parker and McKee 1980). Berra and Au (1978) reported very few cysts of the black-spot trematode *Uvilifer* in this species, and suggested that the fast-flowing water inhabited by Silver Shiners discourages the attachment of the free-swimming larval parasite. Hoffman (1967) reported infestation of this species by the trematode *Neodactulogyrus*.

Man's use of the Silver Shiner in Ontario is limited, but anglers favour this species as a bait minnow for warm-water game fish in the Grand River watershed (Parker and McKee 1980).

Special Significance of the Species

The Silver Shiner does not occur outside the United States and Canada. It was considered threatened in Michigan by Miller (1972) but not in any other states.

The genus *Notropis* cannot be considered threatened in any way, but Miller (1972) listed 33 *Notropis* species as threatened in at least one state and many *Notropis* species in the United States have very small ranges (Lee et al. 1980).

The degree of public interest in this species is low. However, there is a concern by a number of groups for rare, threatened or endangered species in general. Some interest by fishermen exists through their use of the species as bait.

The Ontario populations are the most northern of Silver Shiner populations. They are disjunct from the American range, and are of scientific

interest as possibly genetically different, and because they have been subject to different climatic influences.

Evaluation

The Silver Shiner populations in Canada are the most northern of the species. The Canadian distribution is thus naturally limited and cannot be expected to expand significantly. Apparently, recently or currently increasing populations of Silver Shiners are present in the Grand and Thames River watersheds, but the status of the Bronte Creek population is unknown. The species does not currently appear threatened in Canada due to the actions of people. Limiting factors are not yet known, but gradient may be affecting distribution.

Acknowledgments

The author (M. E. Baldwin) and B. Parker are the current authorities on Canadian Silver Shiner populations. C. R. Gilbert has also done extensive work on the genus *Notropis*.

This report is an update of the status report on the species by Parker and McKee (1984), the use of the initial status report is gratefully acknowledged. The writing of this updated status report, as well as my graduate research, was funded by World Wildlife Fund (Canada). Staff of the Royal Ontario Museum kindly assisted in review of their Rosyface Shiner collection for Silver Shiners. The assistance and encouragement of D. E. McAllister and D. A. Smith in the preparation of this report are gratefully acknowledged.

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Updated Status of the Gravel Chub, *Hybopsis x-punctata*, in Canada*

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Parker B. J., P. McKee, and R. R. Campbell. 1988. Updated status of the Gravel Chub, *Hybopsis x-punctata*, in Canada. Canadian Field-Naturalist 102(1): 158-162.

The Gravel Chub, *Hybopsis x-punctata*, is thought to be extirpated in Canada. It had previously been reported only from the Thames River drainage of southern Ontario at the northeastern fringe of its North American range. The last record was in 1958; recent efforts to capture specimens have been unsuccessful. Siltation is the most likely factor affecting the distribution and survival of the Gravel Chub. It was not specifically protected in Canada, although general protection is afforded through the fish-habitat section of the Fisheries Act.

On pense que le Gravelier, *Hybopsis x-punctata*, est une espèce disparue au Canada. Il n'était présent que dans le bassin de la rivière Thames dans le sud de l'Ontario, à la limite nord-est de son aire de répartition en Amérique du Nord. Depuis 1958, aucun spécimen n'a été capturé malgré les efforts récents. L'envasement est probablement le facteur principal qui nuit à sa répartition et à sa survie. Le Gravelier ne bénéficiait pas d'une protection particulière au Canada, mais il était protégé de façon générale en vertu de l'article sur la protection de l'habitat du poisson de la Loi sur les pêcheries.

Key Words: Gravel Chub, *Hybopsis x-punctata*, endangered species, Thames River, cyprinids.

The Gravel Chub (*Hybopsis x-punctata*) is a small cyprinid (Figure 1) seldom exceeding 7.6 cm in length (see Scott and Crossman 1973 for detailed description). They are rare throughout their range in east-central North America where they are usually found in slow moving, deep, gravel bottomed streams. The species is too rare to be of economic significance or widely known amongst the minnows. As a result very little information is available on its biology and habits.

Distribution

The range of the Gravel Chub is wide, but discontinuous in east central North America (Figure 2). In Canada, this species was known only from the Thames River drainage of southwestern Ontario, approximately 300 km from the nearest American records in Ohio. Ontario populations had been assigned to the subspecies *H. x-punctata trautmani* by Hubbs and Crowe (1956).

Protection

International: The Gravel Chub is considered to be endangered in Kansas (Platt 1974) and has

been recommended for endangered status in Wisconsin (Anonymous 1979). Gilbert (1980) reported it as now extirpated from many localities where it was formerly found in the U.S. The species has been variously listed as under legal protection in Indiana and Wisconsin, and of special concern in Kansas, Kentucky, Minnesota and New York (Platt 1974; Becker 1983; McAllister et al. 1985).

National: The species is not protected in Canada, although fish habitat sections of the Fisheries Act afford general protection. The species was listed as endangered in 1985 by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC) based on a report by Parker and McKee (1987).

Population Size and Trends

The Gravel Chub was known from only two localities in Canada (Figure 3). The earliest collection was of six specimens seined from the Thames River at the Muncey Indian Reserve (approximately 42°48'N, 81°27'W), in 1923 by D. E. S. Brown of the University of Michigan Museum of Zoology (Holm and Crossman 1986).

*The species was originally assigned an Endangered Status in April 1981. In April 1987 COSEWIC approved and assigned a status of Extirpated (see Parker and McKee 1987).

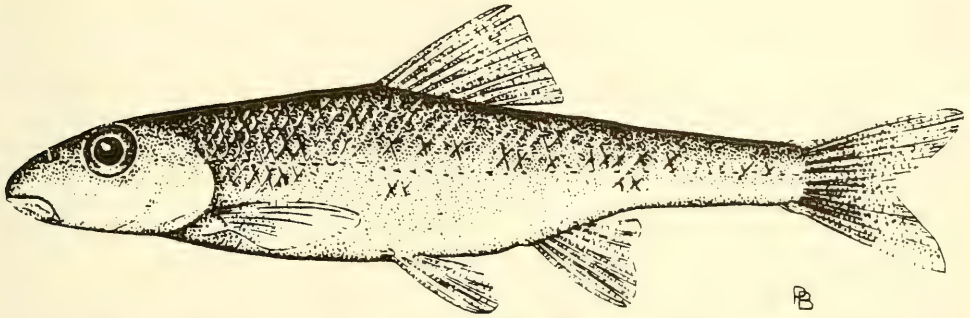


FIGURE 1. Gravel Chub, *Hybopsis x-punctata* (from Scott and Crossman 1973 by permission).

Collections by Dymond and Harkness in 1941 for the Royal Ontario Museum (ROM), at or near the same site, produced no specimens of this species. A. H. McIntyre (possibly a commercial fisherman) took nine individuals of the species in 1958 from a site southwest of the Moravian Indian Reserve at Muncey (Holm and Crossman 1986). Six of his specimens have been catalogued as ROM 20018.

Attempts to collect this species in the early 1970s by personnel of the National Museum of Natural Sciences (NMNS), ROM and the Ontario Ministry of Natural Resources (OMNR) were unsuccessful as were the efforts of Parker and McKee in 1979-80 (Parker and McKee 1980). The scarcity of collected material indicates that populations were localized (Scott and Crossman 1973). Parker and McKee (1980, 1987) suggested that the failure of recent attempts specifically directed to locating specimens at previously known sites left the continued existence of Canadian populations in doubt. McAllister and Gruchy (1977) listed the Gravel Chub as endangered in Canada and this listing was confirmed by COSEWIC in 1985.

Because of the doubt concerning the continued existence of the species two field trips were undertaken by personnel of the ROM on 22-26 July and 20-23 October 1985, specifically to sample at or near previously known sites. In addition, other suitable habitats along a 17 km stretch of the Thames above and below the previous sites were sampled by seining and/or electrofishing (see Holm and Crossman 1986). No *H. x-punctata* specimens were found during the 1985 investigations.

Habitat

In Ontario, the Gravel Chub inhabited sections of the Thames River. Recent conditions at previous capture sites were noted by Holm and

Crossman (1986). The river has a constant flow, is 20-30 m in width and 1-3 m in depth with pool and riffle habitats predominating. Substrate material is composed of sand, rock and stone with areas of soft organics and silt. The water is quite turbid [Secchi disc reading less than 1 m (Holm and Crossman 1986)] because of siltation. Bank cover



FIGURE 2. North American range of the Gravel Chub (after Gilbert 1980).



FIGURE 3. Collection records of *H. x-punctata* in Ontario.

is minimal and instream vegetation is restricted to encrusting and filamentous algae. Water temperatures ranged from 18 to 25°C in July (Holm and Crossman 1986), 21 to 24°C in August (Parker and McKee 1987) and 12 to 15°C in October (Holm and Crossman 1986).

Elsewhere in North America, Gravel Chub have been reported as inhabiting clear to moderately turbid streams with permanent flow and well-defined sand, gravel or rocky riffles where the current keeps the river bottom free of unconsolidated silts and clays (Pflieger 1975; Trautman 1981). Trautman (1981) reported that the species avoided areas with macrophytes, larger species of algae and aquatic mosses. Presumably these areas would show silt accumulation. Moore and Paden (1950) described the preferred micro-habitat of the Gravel Chub as small cavities beneath rocks in riffle areas where the current is reduced.

General Biology

Nothing is known of the biology of Gravel Chub in Canada and little has been reported on this species for American populations (see Becker 1983). Specimens from the North Thames River were 52-57 mm long and, based on data for

specimens from Ohio (Trautman 1981), it is probable that the Ontario specimens were adults. Spawning is reported to occur in early spring on swift gravelly riffles in Kansas (Cross 1967). The food probably consists of epibenthic insects (Parker and McKee 1980). Davis and Miller (1967) found that the taste buds on the Gravel Chub's barbels were extremely large suggesting that this species feeds by probing under rocks and into crevices with its sensitive snout.

Limiting Factors

The habitat requirements of the species are narrow and populations are confined to areas where there is sufficient current to keep the bottom free of silt (see Becker 1983). The species is susceptible to turbidity and siltation (Becker 1983). Increased siltation was associated with the extirpation of this species in many parts of Ohio (Trautman 1981) and Wisconsin (Becker 1983). Inpoundment of riffle areas is also a threat to the species (Becker 1983).

Similar habitat changes in the Thames River drainage may have caused extirpation of the Gravel Chub in Canada. Brown in his 1923 collections described the Thames River as clear,

with a fast current at his capture sites (Holm and Crossman 1986). He described the bottom as sand and gravel with capture depths of up to 5 feet (1.5 m). The 1985 ROM collections suggest a shift in environmental conditions adverse to the species as silt and clay was in evidence at all sites and the water was quite turbid (Holm and Crossman 1986). Holm and Crossman (1986) also found an increase in the abundance of species such as the Spotfin Shiner (*Notropis spilopterus*), a species known for its tolerance to turbidity (Trautman 1981). In addition, less tolerant species such as the Mimic Shiner (*Notropis volucellus*) and the Eastern Sand Darter (*Ammocrypta pellucida*) were absent or in reduced abundance from previous collections (Holm and Crossman 1986).

Special Significance of the Species

The Ontario populations were the only representatives of this species in Canada and the only evidence for the existence of this species in waters of the Great Lakes Basin. Scott and Crossman (1973) suggest that the greatest importance of this species to man may be as an indicator of pollution due to its sensitivity to siltation. Smith (1985) also indicated that the species was a good indicator of water quality.

Evaluation

The following factors were used in the evaluation of the status of the Gravel Chub in Canada:

1. Populations of this species have only been reported from the Thames River drainage in Canada, the last specimens having been caught in 1958 despite recent attempts at capture.
2. There is no recent evidence of reproducing populations in Canada.
3. The Gravel Chub was at the northeastern fringe of its range in Canada. Canadian populations provided the only evidence for the existence of the species in the Great Lakes Basin.
4. This species is particularly sensitive to environmental deterioration in the form of siltation and is important to man as a pollution indicator. The high turbidity and abundant silt found at collection sites in recent years suggests that the substrate of the Thames is heavily silted and less suitable now for a number of species.
5. *H. x-punctata* was probably never abundant in the Thames River and has not been collected since 1958 despite the considerable efforts expended to locate the species.

Based on the information available it is apparent that the Gravel Chub is now extirpated in Canada.

Acknowledgments

This paper is the result of the efforts of many dedicated individuals and much has been extracted from the field work and discussion of the species in Parker and McKee (1980) and Holm and Crossman (1986). Parker and McKee's efforts were funded through the National Museum of Natural Science, The Department of Fisheries and Oceans and Supply and Services Canada. The 1985 ROM surveys were funded by the Ontario Ministry of Natural Resources.

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Status of the Redside Dace, *Clinostomus elongatus*, in Canada*

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Populations of the Redside Dace, *Clinostomus elongatus*, are apparently declining in Canada where the species occurs in only a few streams flowing into Lake Ontario, Lake Erie and Lake Huron in southern Ontario. The range of this species is discontinuous in the upper Mississippi River drainage and in the Great Lakes drainage of the United States and Canada. Populations in Ontario represent the northern range limit of the species. Generally uncommon in southern Ontario, the Redside Dace is still locally abundant at some specific localities. Reproducing populations are present. In some sections of its Canadian range, however, population levels have declined during the past few decades. Although there are no immediate threats to its welfare in Canada, long-term habitat deterioration could threaten the continued existence of this species in southern Ontario. The Redside Dace is not specifically protected in Canada, although general protection is afforded through the fish habitat sections of the Fisheries Act.

Le Méné long, *Clinostomus elongatus*, est menacé au Canada où il peuple seulement quelques cours d'eau au sud de l'Ontario qui se jettent dans les lacs Ontario, Érié et Huron. L'aire de distribution de cette espèce est discontinue dans le bassin supérieur du Mississippi et dans le bassin des Grands lacs au Canada et aux États-Unis. L'Ontario représente la limite nord de son aire de répartition. Peu commun au sud de l'Ontario, le Méné long est encore abondant à certains endroits où vivent des populations reproductrices. Toutefois, son abondance en plusieurs points de son aire de distribution canadienne a diminué au cours des dernières décennies. Même si sa survie au Canada n'est pas menacée dans l'immédiat, la détérioration à long terme de l'habitat constitue un danger pour cette espèce dans le sud de l'Ontario. Le Méné long ne bénéficie pas d'une protection particulière au Canada, mais il est protégé de façon générale en vertu de l'article sur la protection de l'habitat du poisson de la Loi sur les pêcheries.

Key Words: Redside Dace, *Clinostomus elongatus*, cyprinid, rare and endangered fishes, southern Ontario.

The Redside Dace (*Clinostomus elongatus*) (Figure 1) is a small cyprinid found in Canada in a few streams flowing into Lake Ontario, Lake Erie and Lake Huron. This minnow is generally uncommon in southern Ontario although it is considered locally abundant at specific localities. They have conspicuously large, upturned mouths, proportionally larger than any other minnow in the region. They feed on insects at the surface, often leaping out of the water to capture prey. Insects, especially Diptera, make up most of their diet. Mid-water and bottom feeding are of secondary importance (Scott and Crossman 1973).

The body of the Redside Dace is laterally compressed. It has an olive-green, emerald, or steel blue, back. Below this is a golden stripe. A relatively broad, black lateral band runs from the tip of the snout to behind the head, where it becomes white in young, orange in females and young males, and scarlet in adult males;

colouration intensifies during spawning. At the mid-line, the band becomes black again, terminating at the base of the tail. The ventral surface is cream-coloured and the fins are transparent. The sides show a purple iridescence and the peritoneum is characteristically silvery (Scott and Crossman 1973).

The maximum length for Ontario specimens is approximately 8.5 cm Standard Length (SL), reaching a weight of 8.5 g. Females generally attain a larger size than males of the same age class. Maximum age is 3+ years, with maturity and spawning at 2+ years (Scott and Crossman 1973).

Distribution

The range of the Redside Dace in North America is discontinuous and is comprised of several disjunct populations (Figure 2). Canadian populations are separated from those in the United States. In the western states the species is found in

*Rare status approved and assigned by COSEWIC 7 April 1987.

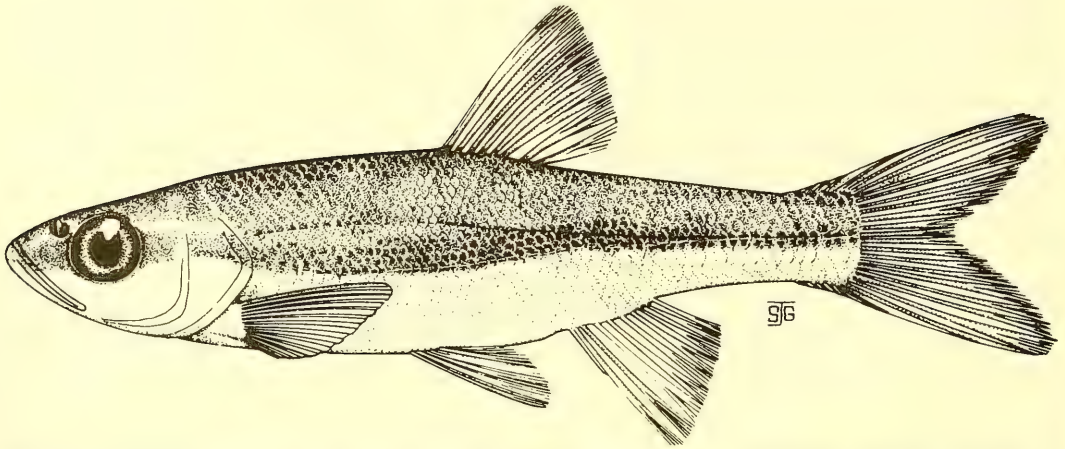


FIGURE 1. Drawing of the Redside Dace, *Clinostomus elongatus* (Courtesy D. E. McAllister, National Museum of Natural Sciences; drawing by Sally Gadd).

the upper Mississippi basin in Minnesota and the upper Mississippi and Lake Michigan basin of Wisconsin. East of Lake Michigan, Redside Dace are now extirpated from Indiana but still occur in Michigan, Ohio, Kentucky, Pennsylvania and Maryland (Moore 1968; Gilbert 1980). In Canada the species is found only in Ontario (Scott and Crossman 1973).

Collection records in Ontario indicate that the general distribution included tributaries of Lake Ontario from Lynde Creek (Ontario County; 43°51'N, 78°57'W) on the east to Spencer Creek (Wentworth County; 43°16'N, 79°55'W) on the west, and north to the headwaters of these systems (Figures 3–4; see Parker and McKee 1980; Holm and Crossman 1986). Distribution in the Lake Simcoe drainage is limited to Kettleby Creek (York County; 44°00'N, 79°34'W).

Apart from this area of general distribution a few small regions of isolated distribution have been reported from the Lake Huron basin in the Saugeen River watershed (Bruce County; 44°10'N, 80°30'W), particularly Meux Creek (Holm and Crossman 1986). The species has also been reported from Gully Creek in Huron County (43°36'N, 81°40'W) in the Lake Huron Basin. Specimens have been collected from the Lake Erie basin in the headwaters of the Grand River system in Irvine Creek, (Dufferin County; 43°50'N, 80°24'W), in the Nith River from an unspecified location in 1982 [Royal Ontario Museum (ROM) 24858 and in the Grand River near Belwood (Wellington County; 43°43'N, 80°22'W) by the

Ontario Ministry of Natural Resources (OMNR), although no specimens were retained (Parker and McKee 1980).

Redside Dace were also reported in 1960 from unspecified localities in the St. Catharines area in Lincoln and Welland Counties (Parker and McKee 1980; Holm and Crossman 1986). There is no evidence that the species occurs in the area now (Holm and Crossman 1986).

Recent collections (Figure 4) reveal some changes to the distribution within the recorded Ontario range. For the most part these reveal a decline within the general area of distribution and will be discussed further under the section on Population Sizes and Trends.

Protection

International: Considered threatened in Michigan (Miller 1972) in recent years and has disappeared from many areas in the United States (Lee et al. 1980). The species is under legal protection in Indiana and is of special concern in Kentucky and West Virginia (Johnson 1987).

National: Not protected in Canada, although fish habitat sections of the Fisheries Act do afford general protection.

Population Sizes and Trends

The Redside Dace is generally uncommon but at one time was locally abundant throughout its range in Ontario. A comparison of capture records suggests that populations of this species are declining and may have been extirpated in some



FIGURE 2. North American distribution of the Redside Dace [adapted from Gilbert (1980)].

watersheds. Wainio and Hester (1973) found the species widespread in the Humber River but not in sufficient numbers to be considered common, whereas Parker and McKee (1980) reported that, where captured, the species accounted for 1–78% of all fish caught. Holm and Crossman (1986) found the species occurring in lower frequencies in their 1985 collections.

Parker and McKee (1980, 1981) indicated that the species had undergone a serious population decline based on their surveys and a review of the literature carried out in 1979–80. Collection of Redside Dace from Pringle, Lynde, Highland, Etobicoke, Twelve Mile, and Welland creeks as well as the Don and Nith rivers had not been made in over twenty years. The species had been known from Sixteen Mile Creek as recently as 1975 but was not collected in 1979 (Parker and McKee 1980). Based on this evidence and the general failure to collect the species in many streams where it once occurred Parker and McKee (1981)

suggested that Ontario populations were threatened.

Reduced populations levels could also be partially attributable to sampling technique as the species utilizes a habitat that might easily be overlooked during sampling. For instance, during the OMNR surveys of the Humber River in 1972, one survey team found the species at only two locations while a second team found it to be widespread throughout the watershed (Wainio and Hester 1973).

Because of the uncertainties as to the status of the Redside Dace in Ontario, further surveys were conducted by E. Holm and E. J. Crossman of the Royal Ontario Museum (ROM) in 1985. These surveys were carried out in and around known areas of distribution in an attempt to determine the present status. This involved not only field surveys in 1985 but also a complete review and check of the documentation of all known previous surveys and collections. The 1985 field surveys also sampled



FIGURE 3. Collection records of *Clinostomus elongatus* in Ontario prior to 1980 [adapted from Parker and McKee (1980)].

several other suitable sites in an exploratory attempt to locate populations not previously known. Stream searches involved seining and electroshocking (see Holm and Crossman 1986).

A large majority of the collection records for the species resulted from the extensive, annual stream surveys conducted by the Ontario Department of Planning and Development (ODPD) [now Watersheds Branch of OMNR] from 1949 to 1959. These records were reviewed as well as those of the ROM, OMNR, the National Museum of Natural Sciences (NMNS) and any miscellaneous records of individuals (notably the Archives of Ontario; Martin 1984, 1985; Steedman 1986). From 1949 to 1959 the ODPD captured Redside Dace at 136 known sites. Between 1982 and 1985, 80 of these sites were resampled or sampled within 2 km upstream and/or downstream of the original location. For 56 sites there is no knowledge of any collections at the site since 1959 (Holm and Crossman 1986), although many are in the same watersheds as sampled between 1982 and 1985.

The 1985 collections and review (Holm and Crossman 1986) also indicated a serious decline of Redside Dace in the watersheds sampled,

confirming the earlier work of Parker and McKee (1980). From 1982 to 1985 *Clinostomus elongatus* was located at only 50% of the sites where it was known previously. The ROM surveys of 1985 recaptured the species at 13 of 38 locations and confirmed it in only one new location: on Fourteen Mile Creek in Halton Region (Holm and Crossman 1986). Based on these results it would appear that populations of the Redside Dace have seriously declined or have been extirpated from the lower reaches of Mimico and Etobicoke creeks west of Toronto and possibly in Highland, Petticoat and Pringle creeks east of Toronto (Lake Ontario system). The number of individuals and/or the area of the watershed occupied by the species in the Don and Credit rivers and Lynde Creek has probably declined as well. Healthy populations apparently still exist in the Rouge and Humber rivers, and Duffins, Morrison, Fourteen Mile, Bronte and Spencer creeks. Even though records from Bronte, Spencer and Oakville creeks are from the 1970s the strength of the populations in the general area would not suggest that the population is threatened (Holm and Crossman 1986).



FIGURE 4. Collection records of *Clinostomus elongatus* in Ontario 1980-1985.

There is no evidence that *Clinostomus elongatus* occurs any longer in Welland or Lincoln counties. The Kettleby Creek (Lake Simcoe drainage) population appears stable as does the Irvine Creek group in the headwaters of the Grand River (Holm and Crossman 1986). The Gully and Meux creek populations of the Lake Huron system would also appear to be holding their own although these populations may be the most vulnerable.

Parker and McKee (1980, 1981) cited records of the species in the Teeswater River of the Saugeen drainage and suggested that the disjunction of the species in Ontario is indicative of a species that was once more widespread. Gilbert (1980) and Trautman (1981) stated that the Redside Dace had disappeared from many areas in the United States where it once occurred and Greene (1935) suggested that the species was moving to extinction. Previous ODPD records also reported the species in the headwaters of the Saugeen but they are not there now (Holm and Crossman 1986). Usually a species may survive in the headwaters of a system even after they have been decimated or

extirpated from mid- or lower sections if the headwater habitat is still suitable.

The recent surveys indicate that many of the populations in Ontario are approaching this point. However adult and juvenile specimens were collected in the recent studies indicating the continued existence of reproducing populations. Yet, the increasingly discontinuous distribution of this species in Ontario indicates that the Redside Dace is becoming less common. Deleterious alteration of natural stream habitat by urbanization, industry and agriculture in Lake Ontario watersheds threaten the continued existence of this species in Canada.

Habitat

In Ontario the Redside Dace commonly inhabits pools and slow moving sections of relatively small headwater streams which have pool and riffle habitat. Stream sections where overhanging bushes and herbaceous plants provide some cover were found to be particularly suitable by Parker and McKee (1980) in their 1979 surveys. Bottom

substrates were usually composed of boulders, rocks, gravel or sand, often with shallow surface covering of detritus or silt. Streams were clear and colourless in conjunction with hard substrates and clear to brown-tinged in streams with organic substrates (Parker and McKee 1980). This species prefers clear water and is quite sensitive to turbidity (Scott and Crossman 1973; Trautman 1981). However, Holm and Crossman (1986) did find the species in some streams of moderate turbidity. Such streams may provide marginal habitat at best and may be indicative of the plight of the species in localities where populations are in decline.

Little is known of temperature and dissolved oxygen requirements of the Redside Dace. Temperature and dissolved oxygen levels at collection sites during August and September 1979 ranged from 14–23°C and 4–11.5 mg/L respectively. Temperatures were usually less than 20°C and dissolved oxygen concentrations were at least 7 mg/l. Scott and Crossman (1973), Gilbert (1980) and Trautman (1981) reported a species preference for cool waters.

General Biology

The following account of the biology of the species is based on Parker and McKee (1980). The maximum length for Ontario specimens is approximately 8.5 cm. Females are generally larger than males of the same age class. The maximum age for Ontario specimens was calculated at three years, age two fish being mature. Spawning takes place usually in May at water temperatures ranging from 16–19°C. Redside Dace may move from overwintering areas in pools to riffles or gravel bars to spawn. The spawning process was detailed by Koster (1939). Egg counts for Ontario specimens ranged from 423 to 1971 eggs per female. Larval development has not been described. Gut contents suggest that this species feeds primarily at the surface on insects; benthic and mid-water feeding is of secondary importance. Juveniles but not larvae have been described (Auer 1982).

Sexual dimorphism in the Redside Dace has been noted in previous studies (Koster 1939; Schwartz and Norvell 1958; Scott and Crossman 1973; Trautman 1981). Males usually have proportionately larger pectoral fins than females and body colouration is more intense on the male, particularly during spawning. Breeding males have small tubercles distributed over the body while

the breeding female has smaller, less widely distributed tubercles (Scott and Crossman 1973).

Predation by other animals on Redside Dace has not been reported. Piscivorous fish species are captured infrequently at, or near Redside Dace capture localities.

Limiting Factors

Destruction and degradation of habitat have been the major factors in the reduction of this species. Siltation and removal of bank cover in streams in urbanized areas have reduced available habitat. The species is now restricted to the headwaters of many streams in which it was once more widespread. Trautman (1981) reported that water quality deterioration resulting from coal mining, industrial and agricultural practices caused the depletion of the species in some parts of Ohio.

Special Significance of the Species

Ontario populations provide the only representation of the genus *Clinostomus* in Canada. As the only minnow which habitually feeds on flying insects which it frequently captures by leaping, this species plays a unique, albeit minor, role in the Canadian aquatic ecosystem.

Evaluation

The following statements were considered valid, after review of the available information, and were used in the evaluation of the status of the Redside Dace in Canada.

1. Reproducing populations of Redside Dace are present in the tributaries of Lake Ontario, Lake Erie, and Lake Huron.
2. The range of the Redside Dace in North America is discontinuous and comprises several disjunct populations.
3. The Redside Dace has recently shown apparent population declines and possible extirpations in Ontario, due to deterioration in habitat quality.
4. The Redside Dace is likely to become threatened in Canada if habitat degradation is not terminated or reversed.
5. The two smaller, isolated populations in the Lake Huron System are probably the most vulnerable and subject to reduction from any further habitat change.

Based on information evaluated, a status of threatened seems too severe. On the basis of present, as compared to past, distributions there is a decline but whether the decline is such that it

threatens the whole of the Ontario populations is in doubt. At this time a status of rare is more appropriate but the populations should be closely monitored, particularly those in the upper Don River and the Lake Huron drainage.

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Status of the Banff Longnose Dace, *Rhinichthys cataractae smithi*, in Canada*

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Lanteigne, Jacqueline. 1988. Status of the Banff Longnose Dace, *Rhinichthys cataractae smithi*, in Canada. Canadian Field-Naturalist 102(1): 170-176.

The native range of the Banff Longnose Dace, *Rhinichthys cataractae smithi*, was restricted to the marsh into which the Cave and Basin Hotsprings drain, at Banff, Banff National Park, Alberta. Its survival at this locality was threatened by the presence of introduced tropical fishes and the alteration of the habitat from the inadvertent disposal of sewage from the Cave and Basin Public Baths. It is suggested that the subspecies should now be considered extinct due to introgressive hybridization with *Rhinichthys cataractae cataractae*.

L'aire de dispersion du Naseux de rapides de Banff, *Rhinichthys cataractae smithi*, était restreinte au marécage où draine les sources thermales Cave et Basin, à Banff, dans le Parc National de Banff, Alberta. Sa survie à cet endroit était mise en danger par la présence de poissons tropicaux ensemencés, et l'altération de l'habitat suite à la décharge des eaux polluées provenant des bains publics Cave et Basin. Il est suggéré que cette sous-espèce soit classifiée comme éteinte à cause de sa hybridation introgressive avec *Rhinichthys cataractae cataractae*.

Key Words: Banff Longnose Dace, *Rhinichthys cataractae smithi*, rare and endangered species, cyprinids, Banff Hotsprings.

The Banff Longnose Dace, *Rhinichthys cataractae smithi*, was endemic to a small marsh fed by the Cave and Basin Hotsprings, Banff National Park, Banff, Alberta. In 1892, when it was first described, this small minnow was very abundant (Renaud and McAllister 1988). Now it is considered extinct due to introgressive hybridization with *Rhinichthys cataractae cataractae*, and pressure from competition and predation by introduced tropical fish species.

These fish (Figure 1) had an olive back, shading to a silvery-white belly. The head appeared wedge-shaped from the side, the body rounded in cross-section but slightly flattened at the caudal peduncle. Its mouth was subterminal with a barbel at the end of the upper jaw. During the breeding season, *Rhinichthys cataractae smithi* developed an orange tinge at the base of the pectoral, pelvic and anal fins, as well as on the lower cheeks, the isthmus and the jugular region. Nuptial tubercles developed on the dorsal surface of the head, the upper surface of the pectoral and pelvic fins, and on the scales. Young Banff Longnose Dace had a distinctive black lateral band, beginning at the tip of the snout and ending near the base of the tail.

The Banff Longnose Dace was found at the outlet of the marsh leading into the Bow River in

association with Brook Stickleback (*Culaea inconstans*) and Brook Trout (*Salvelinus fontinalis*), which prey on minnows. Various other exotic, tropical fish have been introduced into the hotsprings resulting in increased competition for food and nesting sites, and predation on dace eggs.

Distribution

Rhinichthys cataractae smithi Nichols, 1916, was found in a marsh (51° 10'N, 115° 35'W) into which the Cave and Basin Hotsprings drain, in the drainage basin of the Bow River, 1.7 km southwest of Banff, Banff National Park, Alberta (Figures 2,3). The Longnose Dace was first reported in the hot sulphur springs at Banff by Eigenmann (1894) as *Rhinichthys dulcis*. Nichols (1916) described the dace as a new subspecies, *Rhinichthys cataractae smithi*, from specimens collected in the Cave and Basin Hotsprings on 21 July 1915 by H. I. Smith. The subspecies was endemic to Canada.

Protection

The fact that the marsh is located in a National Park offered some level of protection. However the introduction of tropical aquarium fishes [aside from the Mosquitofish (*Gambusia affinis*)] and their survival as reproducing populations posed a

*Extinct status approved and assigned by COSEWIC 7 April 1987.

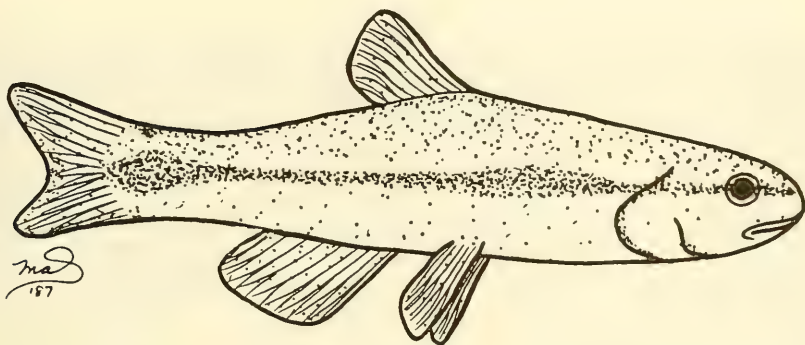


FIGURE 1. Drawing of the Banff Longnose Dace, *Rhinichthys cataractae smithi*, 28.1 mm SL, NMC 81-1160 (Drawing by M. Service, Department of Fisheries and Oceans).

definite threat to the continued existence of *Rhinichthys cataractae smithi*. The Mosquitofish was introduced in 1924 for purposes of mosquito control and was still extant as of September 1981. A local teacher also introduced other species of tropical fishes (J. S. Nelson, Department of Zoology, University of Alberta, Calgary, Alberta; personal communication), of which the existence of the Sailfin Molly (*Poecilia latipinna*) and the Guppy (*Poecilia reticulata*) were confirmed in September 1981, following field work. These three introduced species are present in large numbers, especially the Mosquitofish. The Zebra Cichlid (*Chichlasoma nigrofasciatum*) and the Green Swordtail (*Xiphophorus helleri*) reported by McAllister (1969) and the Jewelfish (*Hemichromis bimaculatus*) reported by Crossman (1984) from the same locality were not collected.

Other than the general protection offered by the Fisheries Act and the fact that the population was located within a National Park, no other specific protective measures were in place.

Population Size and Trend

No census was ever made of the population present in the marsh. The subspecies was described from a collection of 30 specimens [American Museum of Natural History (AMNH) 5514] made in July 1915. A collection made in the early 1900s [National Museums of Canada (NMC) 58-0226] contains 84 specimens. Subsequent collections yielded few specimens. In May 1971, 16 specimens were collected at the inflows (NMC 71-0218); 7 specimens were collected at the same locality in May 1981 [University of Alberta (UA) 4613, UA 4614, UA 4615]. A field trip in September 1981

yielded only two specimens (NMC 81-1159, NMC 81-1160) from a pool at the outlet of the marsh into the Bow River but a few others were sighted at the same place. No specimens were collected at the inflows of the hotsprings or in other areas of the marsh. The decreasing size of collections suggests that the population was decreasing and endangered by 1981 (McAllister et al. 1985). Renaud and McAllister (1988) have indicated that the subspecies is now extinct through introgressive hybridization with the eastern subspecies, *Rhinichthys cataractae cataractae*.

Habitat

The marsh is located at the bottom of the escarpment below the Cave and Basin Public Baths. The Cave and Basin Hotsprings drain into the marsh which drains into the Bow River through one main outlet (Figure 3). This outlet was blocked by a beaver dam in September 1981.

Water temperature in September 1981 varied from 24°C at both inflows of the hotsprings into the marsh to 17°C in the center area of the marsh and at the outlet into the Bow River.

The marsh has an average depth of 1.0 m; some of the deeper pools in the center of the marsh and at the outlet were up to 2.0 m deep. The periphery of the marsh has an average depth of 0.5 m. The tropical fishes are found in pools at the two inflows of the hotsprings where depth ranges from a trickle of water to 0.3 m. Emergent vegetation is present in the shallow areas of the marsh and along the periphery; submergent vegetation, made friable by the calcareous deposits from the hotsprings, is also present throughout the marsh. The center area of the marsh has little emergent vegetation. The



FIGURE 2. Map of the Canadian distribution of the Banff Longnose Dace.

substrate is mud, soft to a depth of 0.5 m, but the water is clear, unless the bottom is disturbed.

The pH at the Cave Hotspring inflow was 8.5; it reached 9 at the Basin Hotspring inflow. It was 8 in the center area of the marsh, and reached 9 at the outlet into the Bow River, which had a pH of 8.5. High pH values can be explained by the high concentrations of total dissolved solids especially carbonates, sulphates and calcium salts (Van Everdingen 1972).

General Biology

Reproductive Capability: Little information is available on reproduction of the Banff Longnose Dace but spawning of *Rhinichthys cataractae* was usually considered to begin in May, June or early July (Scott and Crossman 1973), and occurs in riffles over a gravelly bottom. McPhail and

Lindsey (1970) noted that, although no nest is built, a territory is established and one parent guards the nest. Carl et al. (1967) reported ripe males and females from the Nicola River drainage, British Columbia, at a temperature of 11.7°C, on 7 June 1956.

The specimens of *Rhinichthys cataractae smithi* taken on 17 May 1981 at the Cave Hotspring inflow (water temperature 24°C) showed breeding colours, i.e. orange tinge at the base of the pectoral, pelvic and anal fins, and on the lower cheeks, the isthmus and the jugular area. Nuptial tubercles were also present on the dorsal surface of the head, on the upper surface of the pectoral and pelvic fins, and on the scales.

Species Movement: In May 1971, the Banff Longnose Dace was collected at one of the hotspring inflows to the marsh, when the water

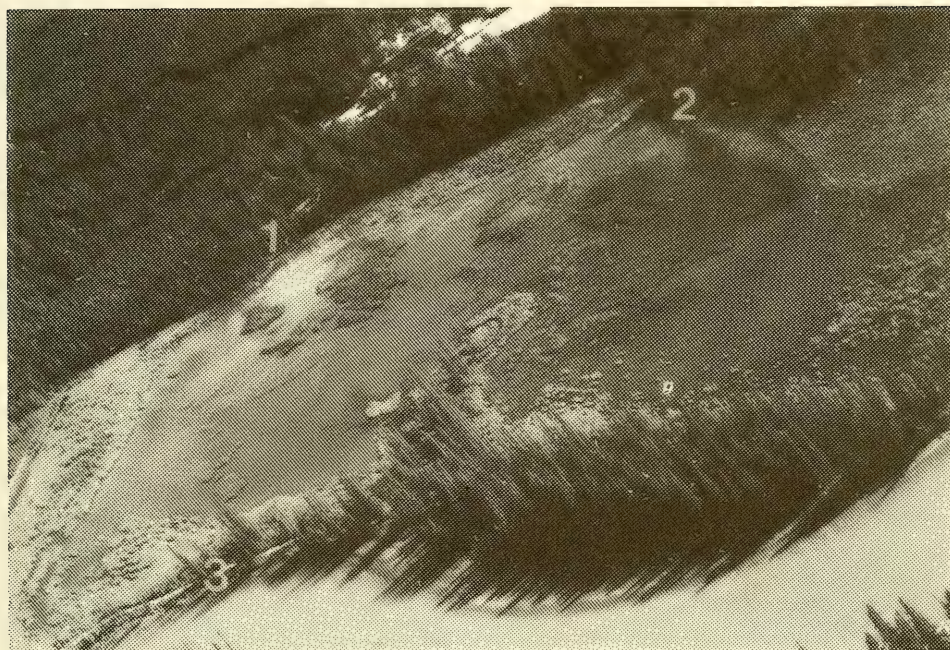


FIGURE 3. Aerial view of the marsh at the inlets of the Cave and Basin Hot Springs, at Banff National Park, Alberta: 1) Inflow of the Cave Hot Spring; 2) Inflow of the Basin Hot Spring; 3) Outlet of the marsh to the Bow River.

temperature was 26°C (NMC 71-0218). On 16 May 1981, one specimen (UA 4613) was collected at the Cave Hot Spring inflow at a water temperature of 22.5°C; five specimens (UA 4615) were also collected there on 17 May 1981, at a water temperature of 24°C. One specimen (UA 4614) was also collected on 16 May 1981 in a pool at the constriction of the bay opposite Basin Spring, where the water temperature was about 21°C. No specimens were collected in that part of the marsh in September 1981, but two were collected at the outlet of the marsh into the Bow River, just above the beaver dam under the foot bridge, at a water temperature of 17°C. This tends to favor the hypothesis that dace move between the hot spring inflows to the marsh outlet at different times of the year. The Banff Longnose Dace is not known to have existed in the Bow River (Renaud and McAllister 1988).

Food: The Longnose Dace is a benthic or bottom-living species and hence its food habits are directly related to bottom-living organisms. The stomachs of the nine specimens of *Rhinichthys*

cataractae smithi collected in 1981 were empty, except for one water boatman, *Ramphocorixa*. Kuehn (1949) analyzed one collection of 196 stomachs of *Rhinichthys cataractae* from southeastern Minnesota taken in June, while Reed (1959) studied the stomachs of 796 Longnose Dace from Pennsylvania taken in September. Gee and Northcote (1963) examined the stomachs of 112 juvenile specimens collected in British Columbia between June and October. In all instances, immature forms of Simuliidae (blackflies), Tendipedidae (midges) and Ephemeroptera (mayflies) made up about 90% of the stomach contents. Gerald (1966) gave information based on all age groups of 439 specimens from Montana from July to September. Baetidae (mayflies) were the most numerous prey in each size group except that Tendipedidae were most numerous in the 50–69 mm size group. Algae had the highest frequency of occurrence in the 0–49 mm group.

Size, age and growth: Apparently, *Rhinichthys cataractae* grows rather slowly. In Minnesota, they have been reported to grow to total lengths (TL) of

48 mm by age 1, 61 mm by age 2, 74 mm by age 3, 86 mm by age 4 and 99 mm by age 5 (Kuehn 1957). In Pennsylvania, they grow to total lengths of 66 mm by age 1, 84 mm by age 2, 92 mm by age 3, 100 mm by age 4, and 118 mm by age 5 (Reed 1959). Both populations exhibited a maximum age of four years for the males and five years for the females. The 108 specimens of *Rhinichthys cataractae smithi* (NMC 58-0226, NMC 71-0218, NMC 81-1159, NMC 81-1160, UA 4614, UA 4615) from the marsh have a standard length (SL) of 18.7–53.9 mm. This would place them in the 1+ age group, assuming they grew at a rate similar to other populations of the species. The effect of the higher temperature of the habitat on growth is not known. Nevertheless, *Rhinichthys cataractae smithi* seemed to be smaller than most populations of *Rhinichthys cataractae*, attaining maximum length of about 54.0 mm SL, whereas others reach 178 mm TL elsewhere (Isle Royale, Lake Superior; Hubbs and Lagler 1964).

Associated species: Seining for the Banff Longnose Dace at the outlet of the marsh into the Bow River above the beaver dam also yielded Brook Trout and Brook Stickleback. White Suckers (*Catostomus commersoni*) and Brook Stickleback were collected below the beaver dam, where the outlet enters the Bow River.

Limiting Factors

There were three principal limiting factors to the survival of the Banff Longnose Dace in the marsh:

1. The introduction of tropical fishes at both hot spring inflows in the marsh was a threat to the continued existence of the dace. The tropical fishes belong to the family Poeciliidae, which are viviparous. The natural breeding season of the Mosquitofish is from April to early October. New broods are produced every 4–6 weeks. They were still spawning on 14 September 1981, at a water temperature of 24°C, along with the Guppy and the Sailfin Molly. They all feed mainly on larval and adult insects, and can also be cannibalistic. They do take vegetable food, especially algae, to a greater or lesser extent (Sterba 1966). In contrast, the Longnose Dace breeds only once a year. Competition for food and direct predation on the dace eggs by the tropical fishes are two possible limiting factors where the species co-habit.
2. The Cave and Basin Hotsprings are the lowest springs on the northeastern slope of Sulphur Mountain in the Bow River Valley. They have been largely covered with the swimming and

bathing facilities of the Cave and Basin Public Baths which have been in place since the late 1800s. The Cave Spring flow is about 1135 l/min at a temperature of 29°C and the Basin Spring flow is about 681 l/min at a temperature of 34°C (Baird 1977). It has been proposed that the water used for the swimming pool should be chlorinated before draining into the marsh. Previously no chlorination occurred. Sewage from nearby public facilities did drain into the marsh but renovations to the facilities will include sewage treatment and the treated sewage will be directed into the Bow River. Chlorination would pose a threat to fish living in the marsh and springs. While much of the free chlorine will likely be driven off through holding in the swimming pool, the chlorine will react with organic wastes to form chlorinated hydrocarbons and chloramines which can be toxic to fish at relatively low concentrations.

3. The construction of the beaver dam and resultant creation of a potential physical barrier to upstream movement of fish should also be mentioned. The migratory habits of the dace are unknown and it perhaps they utilized the Bow River at certain times of the year (e.g. summer), although no specimens have been recorded from the Bow River (Renaud and McAllister 1988). A physical barrier to their upstream movement in the fall may be harmful to the subspecies. This is a matter of some uncertainty both in terms of unknown migratory patterns and the unlikelihood that a beaver dam could prove to be an effective barrier to upstream movements by small fish.
4. During the course of a 1981 field trip, groups of local school children were seen collecting tropical fishes with dip nets at the inflows of the Cave and Basin Hotsprings into the marsh. This practice could be another factor endangering the survival of the subspecies as it has also been collected at these localities by the same method (UA 4613, UA 4614, UA 4625, NMC 71-0218).

Special Significance of the Species

The Banff Longnose Dace had a limited natural distribution in Canada (existence confirmed at only one locality) and thus deserved considerable concern as part of Canada's indigenous fauna and natural heritage. It was also worthy of note because of its rarity as a subspecies and because its presence in that area, along with other endemic taxa (Table 1) suggests that there was an ice-free refugium in the Banff-Jasper area during the Wisconsin era (Crossman and McAllister 1986).

TABLE 1. Other endemic taxa of the Banff-Jasper refugium.

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- a) A blind subterranean amphipod, *Stygobromus canadensis*, from Castleguard Cave, 90 km south of Cadomin, Banff National Park (Holsinger 1980).
- b) A subterranean asellid isopod, *Salmasellus steganothrix*, from Horseshoe Lake, Jasper National Park (Bowman 1975) and from a cave spring near Cadomin (Clifford and Bergstrom 1976).
- c) Two gastropod molluscs (Clarke 1973, 1981): the Banff Springs Physa, *Physa johnsoni*, from the hot and cold springs and their effluents in Banff National Park and the Blunt Albino Physa, *Physa jennessi athearni*, from small lakes in the Banff-Jasper region, and 10 miles downstream of Jasper in a marsh of the Athabaska River system.
- d) Bajkov (1927) described as new to the Jasper region the following fishes:
Salmo irideus morpha argentatus (= *Salmo gairderi argentatus*), *Catostomus catostomus lacustris*, and *Leuciscus nachtriebi athabasca* (= *Semotilus margariscus athabasca*).
-

The taxonomic validity of *Rhinichthys cataractae smithi* as a subspecies has been investigated and verified (Renaud and McAllister 1988).

Evaluation

The following statements were considered valid after review of the available information and were used in the evaluation of the status of the Banff Longnose Dace in Canada:

1. The Banff Longnose Dace was endemic to Canada, where its known native range included only one locality;
2. A reproducing native population occurred in the marsh where the Cave and Basin Hotsprings drain, at Banff National Park, Alberta;
3. A certain level of protection was given the subspecies by the fact that it was located in a National Park;
4. The tropical fishes introduced at both inflows of the hotsprings into the marsh posed a definite threat to the survival of Banff Longnose Dace;
5. Continued eutrophication and chlorination of the marsh water through waste disposal was another factor endangering the survival of the subspecies;
6. Scientific collections of this subspecies may also have been a threat to the animal;
7. The factor or factors leading to the decline of the subspecies also provided the conditions suitable for introgressive hybridization with *Rhinichthys cataractae cataractae* and the extinction of the subspecies.

Based on the information evaluated in this study, it is recommended that the Banff Longnose Dace be classed as an extinct subspecies.

Acknowledgments

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Book Reviews

ZOOLOGY

Mammals in North America.

By Robert E. Wrigley. 1986. Hyperion Press, Win-nipeg. 360 pp.; illus. \$49.95.

This is a unique book on North American mammals. It combines one-page adventure stories, illustrations, and technical information on 115 species. It is a good family book and could be enjoyed not only by youngsters as a picture and storybook, but also used by teenagers and adults as a reference book. One drawback concerning this use, however, is the lack of an index. The table of contents must be scanned in order to find whether a particular species is included.

The technical accounts contain data on size, color, distribution, diet, and reproduction. Species are grouped into eleven North and Central American habitats (tundra, montane, boreal, deciduous and tropical forests, inland waters, cold and warm oceans, deserts, grasslands, and shrublands). A remarks section includes personal notes and anecdotes from the author's extensive experiences. However, these fascinating and humorous stories tend to be overlooked because this section includes data best placed elsewhere. Descriptive information on color, fur, and size would have been better combined under one heading.

The inclusion of adventure stories sets this book apart from other mammal guides. These stories are accurate and believable if one grants the storyteller the liberty of anthropomorphism. Wrigley uses the stories to teach as well as entertain. Not all the stories have a story line; some are a "slice of life" while others speak more generally about the evolution of the species.

The 98 color wildlife paintings that accompany the stories appear well-researched. The habitat and general characteristics of the mammals are accurate and the illustrations frequently correspond to the plots. However, there are problems with perspective and body proportions in many of the paintings.

This book should prove especially useful as a reference source in nature centers, libraries and children's museums. Unfortunately, the retail price of \$49.95 may place this work out of range of many families.

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Ecological Aspects of Social Evolution Birds and Mammals

Edited by D. I. Rubenstein and R. W. Wrangham. 1986. Princeton University, Princeton, New Jersey. 551 pp., illus. Cloth U.S. \$65.00; paper U.S. \$23.50.

From the earliest attempts, the analysis of social behaviour has emphasized the furry and feathered relatives of humans. This attention is in large part due to the diversity in social systems among birds and mammals. The present book provides expert and detailed accounts of our present understanding of an array of these systems on five continents. The first and last of the twenty chapters, by the editors, respectively introduces and summarizes the central theme of the ecological dimensions of social evolution, while the intervening chapters are

grouped under the headings of monogamy and polygyny. Rubenstein and Wrangham introduce the framework which includes the concepts of the maximization of biological fitness by individuals, the adaptive significance of social systems, and the ecological factors influencing mating patterns. The concluding discussion focuses on behavioural variables and social processes, and the sources of sociality in terms of food sources, predation, and intraspecific competition. The crucial distinction of social interactions and consequent relationships is lucidly drawn. Throughout the book, comparative data are presented in order to evaluate hypotheses and justify interpretations.

Seven chapters well illustrate the variety of monogamous social systems which are to be found. Oring and Lank outline how abundant food and intense predation lead to the serial polyandry of spotted sandpipers, and how the experience of individual birds influences their subsequent breeding. Polyandry is also occasionally found in moorhens, as Petrie indicates, in which females compete for small, fat males which incubate the clutch. (This chapter takes the prize for the most significant statistical result: $P = 10^{-15}$). Helpers (mature individuals who assist in the raising of young not their own) are central in the societies of canids and of scrub jays, as Moehlman, and Woolfenden and Fitzpatrick, make clear. Both anatomical and ecological factors influence canid social evolution, while the limitations of suitable habitat favour helping in jays, resulting in decreased losses to predation. Leighton's studies on hornbills in Borneo, together with other data on these cavity-nesting birds, reveal how the distribution of food resources constrains cooperative behaviour by decreasing the foraging efficiency of groups. For the three dozen species of mongooses, Rood distinguishes group-living species feeding on abundant insects and solitary species which hunt small vertebrates. As in many other cases, predation pressures also favour group living. The evolution of sociality is probably based on long-term bonds between a mated pair and mature offspring, just as in canids. In a superb chapter, McKinney considers why dabbling ducks are monogamous, why some are territorial, and why, unlike many birds but like many mammals, it is the female sex which is philopatric. He explains how pairing during the winter months provides for better mate selection, and how the re-pairing each year is a consequence of desertion by the male during incubation.

The eleven chapters on polygamous patterns present a rich sampler of data and ideas. The mating systems of blackbirds, treated by Robinson, are the outcomes of the availability of reproductive females and the amount of paternal care. Andelman shows that the reproductive strategies of cercopithecine primates result from the interactions of fertility, dominance, social bonding, and infanticide. Flinn and Low survey 849 human societies for mating patterns, with emphasis on how availability of resources and avoidance of inbreeding produces marriages between cousins. These authors argue that evolutionary theory can be useful to supplement proximate accounts, such as economic explanations, and to suggest new insights. Gosling dwells

on the manner in which the behaviour of male antelopes is selected to maximize encounters with sexually receptive females. This excessively long chapter is the only one where the lack of an editorial scalpel seriously detracts from the quality of the presentation. A model, and supporting data, of the ecological pressures on sociality in horses and zebras is well presented by Rubenstein. Among marmots, discussed by Armitage, sociality arises from the attraction by males to philopatric females who cooperatively and competitively space themselves according to available resources. The case of gelada baboons is presented by Dunbar whose full book on this species was reviewed last year in this journal. Wrangham highlights the similarities and differences due to food distribution and social behaviour in chimpanzees and bonobos (pygmy chimpanzees). The overview by Gibson and Bradbury of the leks, or mating assemblages, of sage grouse centres on the intricate interactions among males and choices by females. In particular, the data reveal that female choice is based on the features of the male, especially his display behaviour, rather than his location in the lek. Unlike ungulates, kangaroos mingle freely and Jarman and Southwell exemplify this with the eastern grey kangaroo, amid a heavy dose of population biology. Finally, Packer concludes that the sociality of lions, unique among felids, results from preference for large prey, an open habitat, and high population density.

There is a wealth of material in this volume, and almost all of the chapters are well written presentations reflecting excellent research examined in a critical spirit. The illustrations and indexing are helpful throughout. For the most part, description is well balanced by a consideration of relevant theory. The authors have frequently found it important to discriminate among linked aspects of their data, and readers must also make these discriminations if they are to comprehend the analyses. For instance, anatomical data may involve weight, condition (the ratio of weight to length), or the relative conditions of males and females. As always in field studies, attributing causality from correlations is difficult, and the authors are aware of this problem. For instance, does paternal care permit larger clutches or broods, or is it the reverse? The needs for long-term studies, for marked populations, and for data to answer outstanding questions are appropriately pointed out in a number of places. The controversy between the extremists who hold that evolutionary theory will tell us everything or nothing about our own species happily seems to be resolving to a

more moderate position. It is therefore gratifying to see the sensible chapter on humans modestly placed among others rather than omitted altogether or arriving like Santa at the end of the parade (although conservatives may be upset with its placement in the chapters on polygyny). Similarly, those who have complained that the study of social systems has emphasized males unjustifiably will be pleased to see the dominant theme that the energetic and reproductive needs of females are the driving force in many societies. One consequence of this is the evolution of what are termed "hired guns", allies of females who may be

mates or other females. Beyond behavioural ecologists, systematists and evolutionary biologists will find much material of interest, but physiologists, geneticists, and behaviourists interested in proximate mechanisms will find little discussion of these. For its intended scope within behavioural ecology, this book is an excellent presentation of current knowledge and thinking.

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A Coded Workbook of Birds of the World, Volume 1: Non passerines, and Volume 2: Passerines

By Ernest P. Edwards. 1986. Second edition. Published and distributed by Ernest P. Edwards, Box AQ, Sweet Briar, Virginia 24595. 170 pp., Volume 1 U.S. \$12.00, Volume 2 U.S. \$15.00, set U.S. \$26.00.

A Coded Workbook of Birds of the World is a listing of 5513 species from Penguins to Passerines. It is published in two volumes of roughly equal size. Each of the species is preceded by a code which designates the order, family, sub-family (if needed) and the species. This is followed by the scientific name, and the author's choice of English name. Finally, there is a coded designation for the birds distribution. Where appropriate additional symbols tell whether it is extinct, endangered, lumped or split, or has changed names. Only species extinct after 1680/81 are included (no explanation is given for the choice of date). The author states that subspecies, recognizable in the field have also been added to the list. Taxonomic notes are given at the end of each family. Indices by genera, scientific, and English names and a cross reference to codings in the first edition complete the book. Computer diskettes suitable for IBM, PC and IBM compatibles, Macintosh, and Macintosh plus, as well as magtape for large mainframes, are also available by writing to the author. The cost is not specified.

The 5513 species seemed a low number compared to the other estimates I have seen for world species, (generally in excess of 8000) so I looked for recent additions as full species. I found several surprising instances where birds were still lumped. For example, Pacific and Arctic Loon and Black-vented, Townsend's and Manx shearwaters were still listed as subspecies. Only Western Grebe was given. The newly-added Cox's Sandpiper was not mentioned. Conversely Bewicks and Whistling Swan were not lumped.

I was more surprised at the author's treatment of field-recognizable subspecies. I know there are five easily separable subspecies of the Kalij (or Kaleej) Pheasant. The author gives only two, and the scientific names do not correspond to the more recent Indian publications. Just two subspecies of the Yellow Wagtail complex are given. Readily distinguishable forms of Fox and White-crowned sparrows, Black and Red-throated thrushes, and two additional races of the Manx Shearwater are omitted. Black and Black-eared kites are separated but the more striking Pariah Kite goes unmentioned. The Rosy Finch complex is given as two separate species, but the taxonomic notes do indicate they could be lumped. Black Stilt is treated similarly. It is not convenient to completely edit this book as it would require a complete revision. I would warn the prospective user that considerable care is required, especially if subspecies are important.

Computer codes like this are normally created to allow for rapid, flexible, and easy sorting. The author does not explain the basis of the computer version list or what it will do for you. We can assume the database is hierarchical rather than relational as this would appear to be the most useful for creating bird lists. Presumably the code allows the user to classify sightings into year, month, day, or regional lists. For more scientific studies groups could be arranged by family, order, region, etc. However, this is difficult to ascertain without running the disc itself or at least reading a description of the program capabilities.

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Handbook of the Birds of Europe, the Middle East, and North Africa: The Birds of the Western Palearctic, Volume IV: Terns to Woodpeckers

Edited by Stanley Cramp. 1985. Oxford University Press, Don Mills, Ontario. 960 pp., illus. \$146.95.

This is the fourth volume in a series of seven. The three previous volumes cover ostrich to ducks (1), hawks to bustards (2) and waders to gulls (3). The remaining volumes will deal with passerines.

Review of this book is simple. It is an excellent reference work. The writing is clear, the plates are first class, and the distribution maps are splendid. It is very detailed as attested by its 5 cm thickness. The sub-headings will give an understanding of the breadth of coverage. They are: field characters, habitat, distribution, population, movement, food, social pattern and behaviour, voice, breeding, plumages, bare parts, moult, measurements, weight, structure, and geographical variation.

To understand the depth of coverage it is worthwhile comparing with *Birds of Canada*. I consider Earl Godfrey's book one of the best available. As an example of the detail of *Birds of the Western Palearctic*, it devotes almost twice as much space as Godfrey to the Belted Kingfisher, a bird seen only six times in Europe. For the European Kingfisher there is more than five times the information given than for the Belted Kingfisher. This intensity also applies to the plates. The Three-toed Woodpecker is depicted in six different plumages plus two views of an adult male in flight.

In addition to this typical coverage, the authors have made extensive use of sonagrams and there are useful circular moult charts. The eggs of over 100 species are depicted in a set of plates at the rear of the book. The Eurasian Cuckoo (*Cuculus canorus*) is parasitic, so its eggs are shown alongside a representative selection of those of the host species. This plate shows the Cuckoo's amazing ability to mimic the colour of these eggs.

Throughout the text are small line drawings illustrating various aspects of behaviour such as courtship, threat, and so on. They are done by four of the colour plate artists plus one other. Once again they are excellent.

The book finishes with 29 pages of references, in small print, to support the text detail. They are drawn, mostly from journals, from around the world. Finally there are indices in English, French, and German. (Additionally, under the scientific name in the text common names are given in Dutch, Russian, Spanish, and Swedish.)

For the North American reader well over one third of the birds in this volume occur on this side of the Atlantic. Most of the terns, alcids, and owls are common to both continents. A few of the pigeons are here as escaped or released birds. There are several species, like the Belted Kingfisher, which occur as vagrants from our area. This reasoning also applies to the other volumes published to date. So if you buy the most useful volumes I suspect you will be tempted to buy the set, an expensive proposition. There is no doubt, however, that such an acquisition will be very valuable to both the serious birdwatcher and the professional researcher.

In fact the only complaint I can make against this volume is its price. But, as with everything, you get what you pay for and this book is certainly value for money. Perhaps I am also envious as there is no North American counterpart. Before we can hope for this we must all, professional and amateur, fill in the huge gaps in our knowledge. For a start we could attack the list of missing breeding data given in the October 1986 issue of *Birding*.

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Arizona Wetlands and Waterfowl

By David E. Brown. 1985. The University of Arizona Press, Tucson. 169 pp., illus. U.S. \$24.95.

This book is intended to update and enhance an earlier publication on waterfowl in Arizona written by Wesley Flemming for the Arizona Game and Fish Department (*Migratory Waterfowl in Arizona: a management study*. By W. E.

Flemming. 1959). The author feels "much has happened and enough learned to prompt another statewide treatment of an ever popular subject" and his purpose is "to present a general understanding of the character, distribution, and requirements of Arizona's limited wetland resources and the variety of waterfowl that inhabit them."

The volume includes: a historical view of waterfowl in Arizona, general consideration of wetland and waterfowl conservation in this arid state, a very brief description of wetlands within six physiographic regions, a general discussion of waterfowl biology, basic waterfowl management, descriptive accounts of 33 waterfowl species, and a comprehensive reference section. The reference section contains 18 maps which illustrate the distribution of band recoveries of 15 species within Arizona and the intermountain biotic region and a comprehensive metric conversion guide.

The illustrations by Bonnie Swarbrick Morehouse are excellent, especially the full page colour plates of Canada Geese, Black-bellied Whistling Ducks with downy young, Mallards, Mexican Ducks with Class I young, Pintails, Redheads, and Ruddy Ducks with downy young. The majority of the photographs have good contrast with no loss of detail and the line diagrams are very well drafted.

This volume provides the novice waterfowler with a reasonable introduction to many North American waterfowl species and to waterfowl ecology. An excellent aspect of this book is the subtle to not so subtle discussion of the difficulties a state wildlife agency encounters in attempting to manage a consumptive resource and especially in trying to protect waterfowl habitat. Most discussions on the existing waterfowl habitat in this state serve as a reminder of how lightly man treats his responsibility as custodian of the natural resource.

Two small physiographic regions, the White Mountains and San Francisco Plateau, produce the majority of waterfowl within this state, and unfortunately, these areas are threatened by intense human activity. Arizona is a net user of the continental resource with an average annual harvest of 95 000 ducks and geese. Human activity, either industrial, agricultural, or residential, has dramatically affected the regional surface hydrology with the most notable impact being on natural wetlands. The majority of surface waters in the state are impounded and/or channelized rivers, stock watering ponds, sewage lagoons, and industrial outfalls. Most of these waterbodies serve as loafing areas for migrating waterfowl, and are of limited value as breeding areas.

The book has some shortcomings. An addition which would be of immense help not only to residents of Arizona but also for others would be the inclusion of physiographic, vegetation, and topographic maps on which major or significant centres of population are marked. Maps illustrating the distribution of wetlands by physiographic region would also be useful. There is no information on the number, size or distribution of wetlands by physiographic unit nor is there a comprehensive description of the wetland plant and invertebrate communities by wetland type(s) or a description of wetland types. In the chapters on waterfowl biology and management, the treatment of many topics is thin and uneven. For example, the section on waterfowl anatomy deals almost exclusively with plumage in which the accepted terminology for moults is ignored (see Palmer 1972 in *Avian Biology* Volume II edited by Farner and King). Items such as pair bonding, reneesting, philopatry, moult migration, nest site selection, female diets, etc., are either briefly mentioned or omitted. The explanation on disparate sex ratios is confusing and incomplete; a comprehensive discussion of this topic is given by Aldrich (1972 in *Biology of Birds* edited by D. S. Farner). The information on the species descriptions is dated, the treatment is again uneven and thin as the author attempts to integrate the paucity of information from Arizona with material from Bellrose (*Ducks, Geese & Swans of North America*) and other sources. As an example, recent information on the nesting range and population size of Ross' Goose, reported by Kerbes et al. (Canadian Journal of Zoology 1983) and McLandress 1979 (in *Management and Biology of Pacific Flyway Geese* edited by Jarvis and Bartonek), was overlooked.

To conclude, this book is an excellent companion to Pettingill's description of Arizona in *A Guide to Bird Finding West of the Mississippi*, and for the novice waterfowler it is a very good supplement to Bellrose's *Ducks, Geese & Swans of North America*.

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A World of Watchers

By Joseph Kastner. 1986. Alfred A. Knopf, New York, 241 pp., illus. \$36.75.

This book is a carefully researched, sympathetic attempt to understand birders from an historical perspective. It presents bird watching as "the most scientific of sports or the most sporting of sciences."

Kastner, an accomplished author and a former editor of *Life* magazine, enlivens his book with all sorts of interesting anecdotes and appropriate quotations. He gives thumb-nail sketches in suggestive chapter headings of the individuals responsible for the gradual evolution of interest in birds, including Spencer Fullerton Baird, "the recruiter"; William Brewster, "the model watcher"; Elliott Coues, "the prodigious troublemaker"; Witmer Stone and Charles Pennock, "good fellows"; Joseph Grinnell, "the collectors and the shooting controversy"; Thomas Roberts and Althea Sherman, "the independent midwest"; Margaret Nice, "the scientist and her singer"; Elizabeth Dickens, "the imbuer"; John Burroughs, "the great connector"; Chester Reed, Frank Chapman, and Ludlow Griscom, "the Bronx

County Bird Club"; and Roger Tory Peterson, "the guide". Other chapters deal with the forerunners, the Great Sparrow War, the Audubon Society, oologists, and finally, listers by the millions.

Until well after the turn of this century, with the general advent of the field glass, identifications were not acceptable unless the specimen was shot. Descriptions in all bird books depended on having the specimen in hand. Not until 1933 did the advent of Roger Tory Peterson's field guide, which emphasized characters observable in the field, make birding possible in the modern sense.

Kastner concludes: "Somehow one winds up with the feeling that true bird watchers - whatever else they may be - are really the captives of the airy creatures they pursue." As Lowell said, "a bird is singing in my brain." This book is an ideal present for anyone who shares this all-consuming passion.

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Les oiseaux des régions forestières du nord-est du Gabon, Volume 1: Écologie et comportement des espèces

By A. Brosset et C. Énard. 1986. Société nationale de protection de la nature, Paris. 297 pp., illus. No price given.

The authors who have conducted extensive field studies in the Ivindo Basin, Makokou-Belingua region of northeastern Gabon, between 1963 and 1985, report in this first volume on the results of their work. They deal with the descriptive and analytical biology of the bird species of this vast area. A second volume yet to be published will present problems of population and community ecology. In addition to their own observations and data they have included information, published and unpublished, obtained by other observers during and prior to the period of their studies. The Ivindo Basin is characterized by a high bird species diversity, perhaps the highest known: 424 species of which 364 were recorded in a primeval forest area of 2 sq. km near the M'Passa field station where the field investigations were undertaken.

The work is divided into two chapters. In the first, the physical characteristics of the region are given: geographical location, climatology,

vegetation, and descriptions of the study sites. All these sections are brief but contain much information and are abundantly illustrated with well chosen black-and-white photographs.

The second chapter, the most important part of the book (pages 25 to 285), consists in an extensive annotated list of the 424 species recorded in the area but its scope goes much beyond that of conventional annotated lists. For each species the authors give the scientific name and make a statement about its status in the area. They indicate also if specimens exist in collections, if photographs are available, if stomach contents have been obtained, and if individuals have been banded. As an example, I have chosen a species of *Platysteirinae* (Muscicapidae), a group which was particularly well studied by Énard, *Diaphorophis castanea* (Fraser). In this case, the number of specimens available is provided along with the number of banded individuals. As a curator, I wonder why so few specimens have been collected by investigators. Abbreviations indicate if vocalizations have been recorded and the number

of nests discovered. The status of the species is briefly described as "*résident sédentaire*". An extensive section entitled "*Écologie et comportement*" follows and describes the habitat in which the species is found. Information on the feeding habits, territoriality, and density of individuals or pairs is provided as well. Territorial and pair behaviour are briefly described and indications on inter and/or intraspecific behaviour are also given in a few sentences. A short section details the food resources exploited by the bird and is based on field observations as well as on the analysis of stomach contents. It is followed by a part on reproduction in which is summarized the information about nesting such as time of the year, nest description, nest position, nesting material, eggs, laying, incubation, fledgling period, post fledgling period, and hatching success. This section varies greatly in length depending on the species. Numerous black-and-white photographs illustrat-

ing nests or birds appear throughout the text. An extensive bibliography follows the second chapter and a species index concludes the book.

The authors have succeeded in packing an enormous amount of new information in this work, particularly in the section on reproduction. The book is well organized and the information easy to extract. MM. Brosset and Énard must be congratulated for having produced a work of such high quality. I have no doubt that this work will become an essential and fundamental reference for all those interested in the birds of the African equatorial forest. It is my pleasure to recommend highly this book and I look forward to reading the second volume.

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BOTANY

Orchids of Ontario: An Illustrated Guide

By R. E. Whiting and P. M. Catling. 1986. The CanaColl Foundation (Nature Canada Bookshop, Ottawa). xii + 169 pp., illus. \$12.95.

This handbook is a well-produced, welcome addition to the literature on the vascular plant flora of Ontario. Orchids are perhaps the most popular family of vascular plants in the world, attracting numerous professional and amateur growers as well as botanists and naturalists. This guide should be of wide appeal to all orchid fanciers.

Considering the current lack of a complete flora for Ontario, treatments such as this are extremely valuable if they are thorough and comprehensive, as this one is. An introductory section in this book provides the reader with the basics about orchids. Good illustrations, accompanied by a brief text, explain the intricacies of orchid flower morphology. A good non-technical glossary near the end of the book also supplements this section. The introduction also covers the native orchid literature of northeastern North America briefly, and presents a good discussion of the current pressures placed on native orchid populations (habitat depletion, over-collecting for the nursery trade). The authors have presented lists of the endangered, threatened, rare, and uncommon orchids in the province, which should assist the

provincial authorities in their task of deciding which species warrant protection under the Ontario Endangered Species Act.

The bulk of the text is concerned with detailed discussions of the sixty species of orchids in twenty-one genera that have been found growing without cultivation in Ontario. A preamble to this section outlines the basic organization of each treatment, and the methods that were used in gathering data. For each taxon, comments on morphological variation, distribution, habitat preference, phenology, and pollination biology are provided. Each species is represented by a black-and-white photograph. Some of the minor taxa (forms and hybrids) are not illustrated, however. The quality of the photographs is excellent. They add greatly to the utility and aesthetics of the book. It is unfortunate that the photographs could not have been published in color, but of course, the price of the publication would have escalated considerably (and perhaps the book might never have been published at all) if the authors had decided to go with color illustrations. I do have one complaint about some of the photographs, however. Surely, since there are so many people interested in orchids in the province, there must be suitable photographs that were taken in the province for all of the taxa included in the book

(with the exception of *Platanthera ciliaris*, which is probably extirpated in Ontario). This is particularly true of some of our most abundant species, such as *Platanthera hyperborea*. Why was a photograph taken in Newfoundland included for this species? Non-Ontario photographs are also included for *Platanthera clavellata*, *P. dilatata*, and *P. grandiflora*. Several other photographs lack locality data.

The keys included throughout the book, for genera, species, and varieties, are easily understood, and the characters used are reliable. In only one case was the usual dichotomous arrangement of leads not used. A trichotomy is used to deal with a hybrid between *Listera auriculata* and *L. convallarioides*. Some of the species treatments, especially for some of the less common species, contain a great deal of interesting historical information in addition to the biological data that is routinely included.

A few inconsistencies appear here and there in the text. In some places, authorities for infraspecific taxa are omitted. There are also a few literature citations that appear in the text but not in the *Literature Cited* section. The citation of a basionym for a nomenclatural combination that had been published previously is probably a

holdover from an earlier draft of the manuscript. One problem which will make this book less easy to use is the lack of cross-referencing between species accounts and their distribution maps (which are all placed together at the end of the main text). Field botanists will want to refer to these maps continuously, but they will have to do their own cross-referencing. There are a few mapping errors and omissions in areas where I have some field experience, but the overall patterns of distribution reflect the current state of our knowledge.

All in all, my impression of this book is extremely favorable. I consider it to be a thorough, interesting, and useful account of the orchid family in Ontario. The fact that it is a paperback, and is reasonably priced, means that virtually anyone can own a copy, but it also means that it will become tattered in the field pretty quickly. Nevertheless, it will serve as a valuable reference for all field botanists and other orchid enthusiasts in Ontario, and throughout northeastern North America.

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Toronto Islands: Plant Communities and Noteworthy Species

By Steve Varga. 1987. Toronto Field Naturalists, Toronto. ii + 22 pp., illus. \$2 plus \$0.25 postage.

This small booklet about one of Toronto's most significant botanical sites is presumably intended to increase the public's awareness of the natural values of the Toronto Islands. These islands are heavily used for recreational activities during the summer months. There are also permanent homes, an airport, a filtration plant, etc., on these islands at the mouth of Toronto's harbor.

There are chapters on the history of the islands, and on their plant communities. Six communities (wet meadows, lagoon edges, beach strands, dunes, cottonwood woodlands, and sand prairies) are briefly described, and some of the common or unusual species of vascular plants are discussed and illustrated. The illustrations are generally good.

This is not a technical publication, nor is it a glossy booklet that might attract the attention of the recreational public. Although some interesting

species and plant associations are discussed, this is not a complete flora, nor a vegetation analysis, of the islands. There are a few technical errors in the booklet, but I won't dwell on those. If the booklet was intended as a guide for visitors to the islands, then I would have placed the notice to stay on the trails, avoid collecting, and carry away garbage, on the inside front cover. As it is, this notice is on the inside back cover, following an appendix which is probably the last thing that a casual visitor would read.

To be honest, I am at a loss to define the niche of this publication. Even the illustrations (or most of them) have appeared elsewhere (in the Toronto Field Naturalist's newsletter).

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Biology of Lichenized Fungi

By James D. Lawrey. 1984. Praeger, Toronto. 408 pp., illus. U.S. \$39.95.

During the past ten or fifteen years, amateurs in lichenology have seen one new introductory lichen guide after another appear on the market. *Biology of Lichenized Fungi*, it must be stressed, is not one of these.

Rather, it is a technical treatise written primarily for mycologists, algologists, and other professionals in related fields — individuals not likely to break rank and run under a rapid-fire attack of biologese.

Yet for the amateur, especially the serious amateur, this book does possess one important saving grace: its author's stated desire to attract researchers to the field of lichenology. In order to achieve this end, Lawrey has made every effort to provide his readers with a veritable smorgasbord of lichenological delicacies. There is something here, in other words, for almost everybody.

Biology of Lichenized Fungi opens, logically, with a consideration of basic lichen structure ("Vegetative Structure", "Cellular Structure") and reproductive biology ("Reproduction and Dispersal"), and then proceeds to more technical discussions of, first, the fungal and algal partners ("Isolation and Culture of Lichen Symbionts") and, eventually, the lichen symbiosis ("Synthesis", "Whole Thallus Physiology"). In general the remainder of the book will be of greater interest to field naturalists, who should pay particular attention to the chapters entitled "Growth and Demography", "Lichen Community Ecology", and "Lichens and Pollution". The book closes with a bibliography and two indexes: one to species, and one to author and subject.

On the negative side, this book is conspicuously uneven in its treatment of lichen biology. Some topics, especially chemical ecology, are discussed almost *ad nauseum*, while others, including lichen ontogeny, lichen phylogeny, and fungal morphology, are essentially passed over in silence. However, none of these fall within the usual compass of natural history; the naturalist is not likely to notice their absence.

More troublesome than the omissions of the author are those of Praeger, the publisher. To begin with, the design of this volume — flat, staid, perfunctory — can only be compared to that of those anonymous highschool texts of 1950's vintage which turn up again and again at table clearance sales in cheap, second hand bookstores — presumably because no one ever buys them. The illustrations appear to have been reproduced by xerox, and are too often dark, hazy, in some cases almost illegible. As to the text itself, though

mercifully free of typographical errors, on at least two occasions (pp. 246, 294), whole segments of paragraphs appear out of sequence. The index, moreover, is a veritable devil's playground of error and oversight.

On the positive side, *Biology of Lichenized Fungi* admirably performs four functions which, taken together, make this book an important one for North American lichen enthusiasts.

Foremost among these, perhaps, is the review function. Thus, at the head of each chapter or section within a chapter, Lawrey pauses to list the best and most recent review papers on the topic up for discussion. These can usually be depended upon to be complete and, as of 1984, up-to-date, providing an easy point of entry to almost all fields of lichen biology.

A second, related function is the bibliographic one. With a bibliography some 44 pages long, and referencing nearly one thousand titles, *Biology of Lichenized Fungi* offers a serviceable road map to the highways and byways of lichen biological literature. While comparable bibliographies have appeared in the past, none of the current ones have so clear a North American bias.

The third function is the rather obvious one of presenting, in an often leisurely but never torpid prose, the latest findings of lichen research. In a discipline like lichen biology, where earlier premises are being toppled every few years, the layperson's knowledge becomes quickly outdated. *Biology of Lichenized Fungi* goes a long way toward remedying this situation.

The fourth function is that of indicating where future research is required — something Lawrey accomplishes almost to a fault. His text, in fact, is literally strewn with comments of the kind "this hypothesis appears to be worth testing", "nothing is presently known about...", etc. Although most of the research needs identified by Lawrey clearly lie beyond the technical means of the field naturalist, it is not hard to find obvious openings as well. One exciting example (lending itself well to the naturalist mania for collecting) will be found on pages 338 to 340, where the author discusses the role of retrospective trace metal studies in future environmental monitoring.

Hopefully naturalists across the country will ensure that *Biology of Lichenized Fungi* will find a place, if not on their own bookshelves, then on the shelves of the university library nearest them. It is a reference that deserves to be consulted by teachers, writers, and students of lichens everywhere.

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The Agaricales (Gilled Fungi) of California

Edited by H. D. Thiers. Mad River Press, Eureka.

Volume 1: Amanitaceae,

Volume 2: Cantharellaceae,

Volume 3: Gomphidiaceae,

Volume 4: Paxillaceae.

By H. D. Thiers. 1982. 53 pp., 8 color plates. U.S. \$6.95; 1985. 34 pp. U.S. \$3.95; 1985. 20 pp. U.S. \$1.95; and 1985. 9 pp. U.S. \$1.65.

Volume 5: Hygrophoraceae.

By D. L. Largent. 1985. 208 pp. U.S. \$11.95.

These are the first contributions in a well-thought-out series of monographs of California mushrooms. Many of the west coast species, or amphipacific species, will be found further north in British Columbia, and a number of the more widespread species will be found elsewhere in North America. Therefore, these publications are of interest to Canadians. In addition, the west coast flora and mycota, particularly of California, are rich in endemics and disjunct species, hence there are good reasons for such a series.

The set is unbound, each page pre-cut and loose, and therefore, I recommend that the separately ordered, titled ring binder be acquired. The few colour plates with the first volume are excellent and can be inserted in the text near the species description. A dichotomous key to 16 families of gilled fungi requiring the use of a microscope starts the series. Dichotomous keys are provided for all the genera and species treated, and synoptic keys also are included for the species in the two larger genera, *Amanita* and *Hygrophorus*. For each species a full macroscopic description and a shorter microscopic description are supplied. The colours of the different parts of mushrooms in some genera are variable and precise determination of the pigmentation is required to accurately identify many species. Common colour terminology is used in the description but these are supplemented by numbered references to colour terms in either "Ridgway" or "Kornerup & Wanscher," two standard colour guides, which are indexed following the treatments of *Amanita* and *Hygrophorus*. Another feature which makes these publications semitechnical is the listing of voucher specimens by collectors numbers and herbaria where deposited. Both are excellent ideas. The

paragraph on distribution and habitat generally reflects the California scene. For example, *Amanita rubescens* is reported "from San Diego County to the Oregon border," with no indication of further distribution, but the species is reported from 21 states in Jenkins' 1986 treatment of *Amanita* in North America, and it occurs in Ontario, Quebec, and Nova Scotia in Canada. The first five parts cover 25 species of *Amanita*, 4 *Limacella*, 5 *Cantharellus*, 5 *Craterellus*, 4 *Gomphus*, 1 *Brauniella*, 5 *Chroogomphus*, 4 *Gomphidius*, 3 *Paxillus*, 1 *Phylloporus*, and 128 species of *Hygrophorus*, plus several varieties. The largest families, yet to be treated, will need to be covered in sections.

The taxonomic portion at the species level is up-to-date, to the extent that one provisional species is recognized in *Amanita*, as well as a number of new species of *Amanita* only recently described. Also nine unnamed *Hygrophorus* species are described and referred to by number. Three new combinations are validated in *Hygrophorus*, although one was mistakenly labelled a nomen novum. The name *Hygrophorus pseudomarchii*, proposed on p. 81 of the Hygrophoraceae monograph is invalid, i.e. not acceptable according to current convention (no type designated, no Latin diagnosis, no validly published basionym). At the generic level, David Largent's Hygrophoraceae contribution is more conservative than those by the editor. Most agaricologists now divide the Hygrophoraceae into at least two genera, *Hygrocybe* and *Hygrophorus*, but the current treatment recognizes one genus, *Hygrophorus*. In Singer's *Agaricales in Modern Taxonomy*, 1986, subgenus *Pseudohygrophorus* = the genus *Neohygrophorus*, sections *Hygrotrama*, *Hygrophorus* and *Hygrocybe* are all elevated to generic level, and section *Camarophyllopsis* = the genus *Camarophyllus*. In the Paxillaceae, subgenus *Tapinella* is recognized as a distinct genus in our labs.

It is hoped that this quality series will continue to grow and eventually include all the gilled mushrooms of California.

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Native and Cultivated Conifers of Northeastern North America: A Guide

By Edward A. Cope. Illustrated by Bente Starcke King.
1986. Cornell University Press, Ithaca and London.
Cloth U.S. \$39.95; Paper U.S. \$17.95.

This book, which is written for the horticulturalist rather than the botanist, is designed to serve as a means of identifying not only the 18 native conifers but also those species that are grown in botanical gardens and arboreta. Thus some 7 genera including some 1300 species, which may be found in northeastern North America, an area encompassing eastern Canada south to the southern border of Pennsylvania and west to Kansas and North Dakota, are included.

The keys, both to genera and to species, are written using a minimum of technical language and are based primarily on vegetative characters of leaf, twig, and bud. They are accompanied by fine line drawings which are referred to in the keys, that illustrate the genera and species which are being keyed out. The generic and specific descriptions are written in simple terms, but are quite informative.

The unique feature of this book is the alphabetical listing of cultivars following the short specific description. There is no key to cultivars provided, but most cultivar names are followed by a few word description, e.g. under *Cedrus deodara*,

Deodar Cedar, 'Crassifolia' Tree Stiff, stunted; leaves short, thick. In addition, in species where there may be many cultivars, cultivar character groups such as dwarf, slow, rounded, yellow, white, may be given as an aid to identification, or for someone who is searching for a form to be planted in a particular situation, an aid to the best form to select.

Appendixes include: 1) Conifer cultivar character groupings, 2) Conifer families and genera and their distribution, 3) Representative cones and seeds of 27 genera of Conifers, and 4) Conifer twigs. The first appendix is perhaps the most interesting because it provides a guide by which one can be helped to select a tree or shrub for planting in a particular situation.

Although designed for use in northeastern North America, because it includes so many cultivated species, it will also prove useful in western Canada and the United States as well as in much of Europe.

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ENVIRONMENT

A Hierarchical Concept of Ecosystems

By R. V. O'Neill, D. L. DeAngelis, J. B. Waide, and T. F. H. Allen. 1986. Monograph in Population Biology 23. Princeton University Press, Princeton, New Jersey. 253 pp. Cloth U.S. \$45; paper U.S. \$14.50.

There is much discussion among ecologists (most of it futile) about "reductionism" and "holism" and how to do science. The common sense reply to extreme views is that any study benefits by paying attention to smaller scales, where details of mechanism are to be found, and to larger scales, that set environmental constraints. This is the case whether one is studying molecules or solar systems. The concept of hierarchy encapsulates this insight. In the present work the authors attempt first to look at ecosystems from a hierarchical perspective, a task they accomplish very well, and second to demonstrate that the hierarchical perspective leads to important new insights and research questions, a task in which, I think, they fail.

Perhaps the best example of the utility of the hierarchy concept is that it leads inevitably to the conclusion that ecosystems are not complex, or at least are no more complex than any other kind of physical system. This surely is the starting point for any real progress in understanding ecosystems. It is very encouraging to see this basic principle flowing so naturally from the hierarchy perspective.

Another important stumbling block in the road to understanding ecosystems is the vexed idea of "stability" or homeostasis. Cybernetics, a powerful tool often used to analyse ecosystems, revolves around the concept of homeostasis, yet there is little reason to believe that ecosystems are often stable in this sense. The authors point out that "cybernetics is neither the fundamental nor sole organizing principle of ecosystems". They go on to stress the related but perhaps more applicable concept of homeorhesis, or continuity of process. Once attention is focused on processes and rates,

with a wide range of values, as opposed to states, a hierarchical perspective becomes attractive since "the hierarchical structuring of a dynamic system follows with mathematical necessity from the wide differences in rate processes". This is a fruitful and interesting train of thought.

There are many interesting discussions of this sort in the first part of the book. Unfortunately, the second part, on applications, is less successful. Perhaps the weakest part is the chapter on hierarchies of species. This turns out to be a backwards-looking, almost antique restatement of ideas current in community ecology ten or fifteen years ago. For example, a major conclusion is that "the empirical studies indicate that food webs tend to contain an internal organization. ... The result is a hierarchical structure that both analytical and simulation studies indicate should enhance stability". Here and elsewhere, the word "hierarchy", as far as I can see, is both grammatically and conceptually redundant. Two following chapters, also on applications, are

somewhat more successful, but new and interesting applications are few and far between.

A wide general audience was made aware of the idea of hierarchy (if not the word) by Douglas Hostadter's splendid *Godel, Escher, Bach* of 1979 (Vintage Books, New York), and ecologists were given hierarchy theory explicitly a few years later (T. F. H. Allen and T. B. Starr. 1982. *Hierarchy*. University of Chicago Press). The present work is more technical and more ecologically sophisticated than either, yet I am not sure it is much of a conceptual advance. So, although it will be useful as an advanced text book (and I will use it as such), I doubt it will make much of an impact on ecosystem theory. In short, I disagree with the authors when they say hierarchy theory "is a new way of looking at ecosystems".

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Rationale for Sampling and Interpretation of Ecological Data in the Assessment of Freshwater Ecosystems

Edited by Billy G. Isom. 1986. ASTM Special Technical Publication 894. Philadelphia, Pennsylvania. 193 pp., illus. U.S. \$39.

This collection of papers from a 1983 symposium by the same title, discusses the sampling, analysis, and interpretation of data relating to the effects of impacts on aquatic ecosystems. The book consists of 12 articles contributed by 26 authors. Ten of the papers are directly related to the topic of the symposium as expressed in the title and the summary, one is related only tangentially and one not at all. The 10 papers that address the problems of sampling and interpretation of ecological data are evenly divided among those that take a case history approach and those of a more conceptual approach. Among the case history papers, Kovalak, Dennis, and Bates evaluate the effort required to estimate the density of rare species of mussels using various sampling methods, while Isom and Gooch investigate the effectiveness of different sampling methods for quantitative surveys of mussel communities in large streams and lakes. Adams, Hoogheem, and Michael discuss criteria for collecting and interpreting data for aquatic hazard evaluation of toxic chemicals. They illustrate their ideas with an assessment of the hazard posed by a particular

industrial waste product. Metzger uses data from studies and theoretical considerations on groundwater quality to argue that care is needed to interpret the results of groundwater monitoring. Leland and Carter use data from an experimental study of the effect of copper on stream periphyton to compare the effectiveness of ordination techniques in revealing relationships among periphyton responses to the treatments.

Kratz, Magnuson, Bowser, and Frost present their rationale for a long-term monitoring program of the effects of acid rain on lakes. Sampling is designed to permit comparisons among lakes, seasons, and years for changes in physical, chemical, or biotic parameters. Brown and Dycus discuss the important and difficult problem of distinguishing natural environmental variations from the impacts under study. Horner, Richey, and Thomas describe the conceptual basis for EPAM, a computerized guide to the design of electric power plant aquatic monitoring programs. This is a hierarchical program that consists of four levels of organization to accommodate different levels of information available to the user. Stevenson and Lowe review the many types of data on periphyton that can be sampled. They make suggestions for design of studies that include algal

monitoring and the appropriate statistical methods for analyzing data. Cairns and Pratt present a checklist of tasks to be completed at the start of a monitoring program's design that should be answered before sampling begins.

The paper by Hendricks on leaf processing in reservoirs is related to the symposium topic only in that the author argues that an experimental approach can be applied in field studies. Hill's paper on the role of macrophytes in the nutrient budgets of aquatic ecosystems, while interesting in

its own right, has no bearing on study design and interpretation.

The long delay in publication has resulted in some of the papers being less topical now than when they were presented. Despite this, I think the book will be of interest to those involved in aquatic ecosystem assessment.

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Rivers and Lakes in New Zealand

Photographs by Graeme Matthews. Text by Kenneth Cumberland. 1985. Whitcoulls, Christchurch, New Zealand (North American distributor ISBS, Portland, Oregon). 128 pp., illus. U.S. \$29.95 plus \$2.25 postage.

This is a book to move the spirit and calm the soul. Graeme Matthew's superb collection of photographs reveals contrasting features of New Zealand's inspiring lakes and rivers. Often a lake or river is the centrepiece of a magnificent scene. Sometimes the sheer power and beauty of rushing water, or the patterns made by a broad river in a wide channel, or the colours of the settling ponds of the salt works at Lake Grassmere, are the essence of the photograph. Other times a mere trickle of white water in a cascading waterfall is contrasted with the greens and textures of the surrounding New Zealand bush, or complete stillness on the surface of a large lake mirrors the beauty of towering snow-covered mountains in the distance.

The grandeur of remote wilderness places is contrasted with scenes of man's impact upon rivers, lakes, and the countryside. A meandering stream makes an eye catching squiggle through green farm land, the blue-and-white patterns found in the settling ponds of the paper mill industry are photographed dramatically from above, the engineered water canals with their disciplined contours are contrasted with untamed rivers. Towers built beside rivers, and interesting bridges across rivers are featured, often from unusual angles or with interesting lighting effects. There are several photographs showing the recreational use of the waters, from peaceful canoeing to a dramatic jet boat capsize in a turbulent, muddy river, from peaceful fishermen and even the fish, to action shots of water skiers and people rafting. Canadians may find amusing the few dramatic photographs showing ice formations on rivers and lakes in New Zealand.

These add texture and contrast to the other pictures in the book.

The 15 pages of text, contributed by Kenneth Cumberland, are disappointing. They start with a single page, grey and white topographical map of the whole of New Zealand, on which names are in tiny print and many of the smaller, less known rivers and places mentioned are not indicated. The writing style is awkward. For example, an isolated, one-sentence paragraph reads: "Along with its lofting elevation, New Zealand has a broken irregular and corrugated surface." The theme follows an historical perspective from the Ice Age to the present and this results in a very disjointed presentation of geographical information, with the same river being referred to several times in different places in the text. Some confusion results when the author, in comparing and contrasting information about rivers and lakes, moves from the North Island to the South Island with no warning to the reader.

It has been a pleasure in the process of reviewing this book to offer it to Canadians travelling to New Zealand, and to New Zealanders who know their country. All have paused and contemplated the artistic features of the photographs, and all have enjoyed seeing the book. Everyone reacts to some pictures with the questions, where is that? or will I see that? (or have I seen that?), and in very many cases the answer is no. This book is not a guide for tourists. Graeme Matthews has done much travelling on foot, by canoe, and in ways that allowed him to take superb aerial photographs, often in relatively remote areas of New Zealand that few people visit. This is the charm and fascination of this book.

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Bogs of the Northeast

By Charles W. Johnson. 1985. University Press of New England, Hanover and London. 269 pp., illus. Cloth U.S. \$25; paper U.S. \$12.95.

"Peatlands of northeastern United States" might be a more accurate if less catchy title for this well written and beautifully illustrated paper back. It was written with the field naturalist in mind, especially for those who may have overlooked the bounty and the uniqueness of these habitats. This book also has much to offer the professional biologist because of its thorough treatment of the subject as well as the inclusion of much that is likely to be new to the reader.

In language which is easy to understand, the basic terms associated with bogs and fens are defined. This chapter not only serves as a good introduction for what follows but is indispensable for penetrating the more technical literature on these ecosystems.

Johnson then defines and describes the bogs of his title. He differentiates between coastal and continental, northern and southern, mineral rich and mineral poor bogs and fens. The various geological, topographical, and hydrological factors which distinguish each subtype are explained and useful comparison lists of indicator plants which characterize each subtype are given. The careful naturalist will be able to recognize the bog and fen types of his region. In this respect, this book is equally applicable to the peatlands of southern Ontario, Quebec, and the Maritimes.

The strength of this book is that the author has focused on the peatlands as ecosystems. He explores their recent origins and explains how the differing water, mineral, and topographical features maintain these distinct habitats, or alternately how changes, both natural and man-made, may alter them.

There are several chapters devoted to the unique plants and animals of these regions and more

complete lists of species are provided in the various appendices. Some groups are of course better known than others; the insects, apart from the butterflies, are still poorly studied. A chapter on carnivorous plants particularly appealed to a couple of enthusiastic sixth graders, a testament to the clarity of the language and the quality of the illustrations. The chapters on sphagnum mosses and sedges encourage one to attempt to learn the commoner species of these difficult groups. These chapters were not, of course, intended to substitute for keys or more complete field guides to species.

The inclusion of the myths associated with bogs and fens and the various human uses to which such wetlands have been subjected, round out this little book and make it a unique contribution to the literature. Readers may be surprised to learn that Finland has been experimenting with sewage treatment in the bogs and that Russia consumes over 200 million tons of peat annually as a source of fuel. The author points out that these countries (and Canada) have many more square miles of this peatland formation whereas the northeastern states have at best only small remnants left. The whole book is in effect an eloquent plea to appreciate and to preserve what remains.

The committed bog and fen walker will particularly enjoy the list of peatlands arranged by state and appended to this book. Because of their fragile nature, many smaller bogs and fens have been wisely omitted from this list.

This is an admirable field guide to a unique set of habitats and I am pleased to recommend it.

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Impact of Acid Rain and Deposition on Aquatic Biological Systems

Edited by Billy G. Isom, Sally D. Dennis, and John M. Bates. 1986. Special Technical Publication 928. ASTM, Philadelphia. 114 pp., illus. U.S. \$22.

This is a collection of papers from a 1984 symposium of the same name. The lead paper by Malanchuk et al., of the United States Environmental Protection Agency describes the organization and goals of the National Acid Precipitation

Assessment Program (NAPAP) in the area of aquatic effects assessment. NAPAP is an ambitious program that draws upon data from many sources, including historical chemical and biological data, as well as the results of funded research, in an attempt to more clearly define the effects of acid deposition. The authors discuss in particular the problems with using historical data

of various quality in correlating changes in fish population levels with water quality over time. Crisman et al. assess the importance of littoral and benthic autotrophs in acid lakes. Though usually of considerable importance in small lakes, in acidified lakes littoral and benthic autotrophic communities assume even greater significance because of nutrient limitations on pelagic producers. The authors suggest that the littoral zone has a much greater influence on the better studied pelagic zone than generally is recognized, and that future studies of the process of acidification in small lakes should concentrate on quantifying littoral-pelagic linkages.

Parent et al. studied the effects of episodic and continuous acidification on periphyton production and biomass in artificial streams. Under episodic acidification, production increased in the first 12 hours, then decreased significantly, and thereafter recovered slowly, while biomass was significantly lower in acidified channels. After 33 days of continuous acidification, primary production and biomass were significantly higher than in control channels, and remained so until the end of the experiment. Lam et al. discuss their studies of factors influencing productivity of the Turkey Lakes Watershed. They found the productivity correlated with increases in pH, alkalinity, and dissolved inorganic carbon rather than more constant nutrients, light, and temperature. They discuss the relationships of these factors with watershed hydrology. Allan and Burton found sensitivity to pH among three stream invertebrates to be size-dependent, with small individuals of each species more susceptible than larger individuals. Perry et al. investigated the buffering capacity of littoral and pelagic sediments of soft water lakes. In laboratory studies the authors found that chemical processes and microbial sulfate reduction tended to counter acid addition to an extent greater than anticipated in these lakes. Morgan et al. describe an automated,

satellite linked biomonitoring program designed to provide virtually real-time impact assessment. In the studies described, fish are placed in chambers having activity sensors connected to data monitors and a radio transmitter that periodically sends data via satellite to ground monitoring stations located some distance away. Unusual activity of the fish, presumably due to stress from acidification of the stream, can be detected almost instantaneously by scientists in the laboratory. The goal of these studies is to develop technology that would permit the siting of automated stream liming equipment in remote areas. The paper by Young examines the practice of biologists of using aluminum salts in laboratory studies of acidification effects without considering the concurrent changes in anion concentration. Young suggests a protocol based on aluminum hydroxide to overcome these problems. Finally, Boyle et al. describe a method for measuring pH in low conductivity water, such as rain water. This method is based on increasing the conductivity of the sample without affecting its pH. They do this by adding a small amount of KCl solution to the sample and measuring the pH with a Ross electrode.

The long pre-publication delay has dated this volume considerably. NAPAP has gone through two program reviews since the presentation by Malanchuk et al., the procedure described by Boyle et al. is now available commercially from a supplier of environmental test equipment, and Morgan et al. are developing *in situ* biomonitoring methods for insects. Despite these drawbacks, the papers in this volume should be of interest to those studying acid deposition effects on aquatic ecosystems.

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MISCELLANEOUS

The Physiography of Southern Ontario

By L. J. Chapman and D. F. Putnam. 1984. Third edition. Special Volume 2. Ontario Geological Survey, Toronto. 270 pp., illus. + map. \$20.00.

Southern Ontario has been long known to glacial geologists as a classical landscape for landforms formed during the great ice ages. To non-geologists, the tear-drop shaped drumlins, rolling morainic and kettle topographies, the stair cases of relict shorelines, or the wave-washed bedrock pavements have been important in providing a photogenic backdrop for the fine display of autumn colours, in dictating land-use and settlement patterns, or in some instances for abundant local economic resources for one of Canada's most populous regions. *The Physiography of Southern Ontario* fulfills well the interests of both groups.

The revised third edition of *The Physiography of Southern Ontario* was published by the Ontario Geological Survey, 33 years after the appearance of the first edition. The first two editions were written by Chapman and Putnam, however Putnam died in 1977 leaving Chapman to undertake the third revision alone. Chapman's in depth knowledge of and dedication to studying the geomorphology of Southern Ontario long after his retirement in 1973 is reflected clearly by his continued commitment to publishing both scientific papers and this latest revision of his book.

The volume begins with a brief description of the bedrock which emphasizes the contour of the bedrock surface; an important aspect when one is concerned with the composition, distribution, and morphology of the overlying glacial deposits.

The next chapter emphasizes the historical glacial geology, beginning with deposits older than the last, Wisconsinan glacial phase, through those of the latest Wisconsinan glacial phase, and progressing to events during post-glacial time. Following descriptions of formation of the complex moraine, spillway, drumlin, esker, and glacial lake systems, a series of 15 paleogeographic maps lucidly portray the chronological origin and distribution of these features.

The next 69 pages includes detailed descriptions of each of the individual physiographic complexes: moraines, drumlins, eskers, relict lake features, loess deposits, river valleys, and modern drainage basins. The updated accompanying folded wall

map is referred to for description of these physiographic patterns.

The largest section of the book is devoted to description of each of 55 physiographic regions. With the area of the Canadian Shield south of North Bay, this third edition recognizes three new physiographic regions. This subdivision is based primarily on the structure of the bedrock and the distribution pattern of glacial features. The soils, and land-use and settlement patterns usually follow these physiographic subdivisions. Perhaps this is the most important section of the book.

A series of appendices list sources for more detailed information in Geological Survey of Canada, Geological Survey of Ontario, and other publications. A glossary of geological terms complete the volume.

As stated in the preface, originally *The Physiography of Southern Ontario* was written to provide a basis for description, mapping, and classification of soils. The information contained in the book proved invaluable to engineers, hydrologists, environmental planners, exploration geologists, and school teachers. This new geographically expanded, updated, and more graphically illustrated version will continue to be a practical guide and standard reference.

The volume has few weaknesses. One might find the lack of detailed stratigraphic and chronological descriptions to be a major oversight. However, the author makes no apology for this in the preface, probably because such matters are largely academic which would detract from the general practical focus of the book. It is a pity that several typographical errors and author errors in the References escaped the careful attention of the editors.

Even though this edition is considerably more expensive than earlier ones, its attractive binding, illustrations, wall map, and high-quality paper justify the price. In view of inflated book prices these days, it is a bargain. Everyone with their varied interests in the landscape of southern Ontario will find this book invaluable.

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Biological Museum Methods Volume 1: Vertebrates and Volume 2: Plants, Invertebrates, and Techniques

By George Hangay and Michael Dingley. 1985. Academic Press Australia, Sydney. 379 and 323 pages, illus. U.S. \$75.00 and U.S. \$58.00.

Natural history museums have needed a single reference bringing together the scattered literature on collecting, preserving, storing, and displaying biological specimens. These two volumes partly address the need.

As primers they achieve considerable success, but unfortunately they attempt too much in too little space by including a marked emphasis on display taxidermy and related exhibition techniques. This subject therefore overshadows the more basic museum needs of collecting, preserving, and storing scientific collections, while the ongoing conservation of biological collections is hardly addressed at all.

Major chapters within the books suggest their contents and organization. Volume 1 contains: a short history of taxidermy; fishes; amphibians; reptiles; birds; mammals; embalming; anatomical preparation; freeze drying; and skeletal preparation. Volume 2 carries on with: the methods and procedures of preparation; plants; sponges and coelenterates; echinoderms; worms and worm-like animals; molluscs; arthropods (crustaceans) and chordates; arthropods (insects and others); freeze drying; plastic display box manufacture; plastics workshop; embedding and workshop safety; modelmaking; and dioramas. Orders and classes given above have sub-divisions with titles like: collecting; preparation of scientific specimens; preparation for display purposes; taxidermy; references; and source material. Interestingly, plastic boxes for displaying wet specimens cover 28 pages while dioramas have 15 pages, fish get seven pages on collecting and preserving but 38 pages on preparing and casting them for display purposes, and mammals are given 115 pages with 81 of them on taxidermy.

As introductions to their subjects these books have value, as I found in scanning the sections on collecting and preserving invertebrates, areas in which I have limited experience. However, a careful reading of field techniques for mammals revealed little I could add to what I learned 40 years ago.

Through recent years there has been a growing awareness in a few museums that serious problems

of long standing remain unsolved in the techniques used to store and conserve biological specimens, while some scientists have been changing traditional techniques in field collection and general preservation. As examples of these: using insecticides to protect collections of dried specimens is increasingly difficult since, predictably perhaps, chemicals that kill or repel insects are often found to be unhealthy for museum workers as well; and it is now evident that most bird and mammal specimens in museums have limited value because little more than skin with hair or feathers attached has been preserved. In the first case, the price of healthier museum staffs appears to be more frequent insect outbreaks. In the second case, there is not much of the original animal preserved in most older specimens, because museums tended to throw away the animal while saving little more than its leather "wrappings". These books do not address such problems, which is not surprising since many museum employees seem unaware of such essentially scientific concerns.

Several years ago I became aware that Australia is experiencing a remarkable boom in museums, replacing municipal buildings in three or four state capitals and building an impressive national museum, the first ever, in Canberra. To add to the wonder, the state museums already had impressive staffs of curators in charge of orders or classes of organisms, many with specializations in an invertebrate phylum, and these people have been active annually in vigorous field collecting. Together these have constituted a remarkably active national biological survey. Just possibly Australia is now leading the world in the field work preliminary to taxonomy, biogeography, and related museology. In this time of widespread biological exploration and collecting, these two "how-to" books were probably conceived and produced to fill a national need, combining scattered international literature with Australian experience to produce references for inexperienced staffs. In this they succeed but, as with most books, I suppose, they could be better.

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Museum Collections: Their Roles and Future in Biological Research

Edited by Edward H. Miller. 1985. British Columbia Provincial Museum, Occasional Papers Series, No. 25. 219 pp., illus. \$20.

Recessionary times and restricted budgets have resulted in many museums being increasingly scrutinized for cost effectiveness, and in pressure to increase display and extension functions at the expense of collections and research activity. The public, and even some members of the museum community, have questioned the value of collections never seen by museum visitors. These trends have stimulated at least some museum directors and curators to critically examine the past, present, and future research value of biological collections under their care, and to prepare the papers for this publication.

The book is a collection of 16 scholarly papers in the form of essays or reviews (largely the latter). It was instigated by Yorke Edwards, formerly Director of the British Columbia Provincial Museum, and capably edited by Dr. Edward Miller of the same institution. The papers largely concern biological collections rather than artifacts or cultural materials, and the perspective is North American. Ten of the 17 contributors are Canadian, the remainder represent United States museums. The subject matter is mainly relevant to museums large enough to house significant collections and to employ specialist curators and research staff, i.e. the various Provincial Museums in Canada and the larger university collections.

An introductory paper by Yorke Edwards and a concluding one by Henri Ouellet both stress the general contributions to both pure and applied research that have already been based on museum collections, and the great potential of such materials for further research. The papers in between impressively document this contention in specific and diverse subject areas such as the evolutionary study of growth and development, comparative anatomy and phylogeny, molecular systematics, geographic variation, botanical collections, phytogeography, paleobiology, social behaviour, life-history studies, ecological morphology, animal adaptation, and environmental impact studies. Additional papers reflect on the significance of type specimens and old collections, and the relative goals of museums and botanical gardens. Scientific documentation is impressive,

with up to 177 literature citations per paper. As noted in the preface by Edward Miller, museum collections have also been important for research in areas not reviewed in this volume, i.e. wildlife biology, parasitology, and prokaryote systematics.

Common themes are that new and innovative techniques can be used to glean new information from existing collections, and that expanded collections, new materials, and new preservation techniques must be adopted if museum research is to meet new challenges.

This collection of papers should be of interest to museum curators, scientists, managers, and directors anywhere in the world. Although review articles do not lend themselves to abstraction, more consistent summarization of the major points of each paper, and a synthesis of the entire compendium that is more extensive than provided by the preface, would have been useful. Only six of the 16 papers, some of which are quite lengthy, have summaries or concluding remarks.

The book is too technical and specialized to be of much interest to the public or to the politicians, management committees, and treasury boards upon whom most museums rely for funding. In this regard, a short paper synthesizing the many research contributions that have been based wholly or partly on biological collections, written in layman's language, would have been a valuable addition. Failure to include such a synthesis seems sadly to confirm the assertion of Henri Ouellet that most museum curators have "failed miserably" to inform the general public of the importance of research collections.

Perhaps the major significance of this publication is that its very appearance signifies that museum scientists recognize the dilemma they find themselves in, see themselves as at least partly responsible, and accept that they must become more imaginative and must develop strategies to convince the public and funding agencies of the value and importance of their collections and research.

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NEW TITLES

Zoology

Acid toxicity and aquatic animals. 1987. Edited by R. Morris, E. W. Taylor, D. J. A. Brown, and J. A. Brown. Cambridge University Press, New York. c300 pp., cU.S.\$49.50.

The ancestry of vertebrates. 1987. By R. P. S. Jefferies. Cambridge University Press, New York. c376 pp. cU.S.\$75.

An annotated bibliography of the pike, *Esox lucius* (Osteichthyes: Salmoniformes). 1987. By E. J. Crossman and J. M. Casselman. Life Sciences Miscellaneous Publication. 408 pp. \$18.

Ant cities. 1987. By Arthur Dorros. Crowell (Distributed by Fitzhenry and Whiteside, Markham, Ontario). 32 pp., illus. \$17.95.

†**Auks: an ornithologist's guide.** 1987. By Ron Freethy. Facts on File, New York. 208 pp., illus. + plates. U.S.\$24.95.

Biology of the land crabs. 1987. Edited by Warren W. Burggren and Brian R. McMahon. Cambridge University Press, New York. c350 pp., illus. cU.S.\$49.50.

***Breeding birds of Ontario: nidiology and distribution, volume 2: passerines.** 1987. By George K. Peck and Ross D. James. Royal Ontario Museum, Toronto. xi + 387 pp., illus. \$36.

†**Butterflies of Costa Rica and their natural history: Papilionidae, Pieridae, Nymphalidae.** 1987. By Philip J. DeVries. Princeton University Press, Princeton. xii + 327 pp., illus. + plates. Cloth U.S.\$60; paper U.S.\$22.50.

Butterflies of the Himalaya. 1986. By M. S. Mani. Junk (U.S. distributor Kluwer, Norwell, Massachusetts). x + 181 pp., illus. + plates. U.S.\$79.50.

The Cayo Santiago macaques: history, behavior, and biology. 1986. Edited by Richard G. Rawlings and Matt J. Kessler. Based on a symposium, East Lansing, Michigan, 1983. State University of New York Press, Albany. xiv + 306 pp., illus. + plates. Cloth U.S.\$39.50; paper U.S.\$14.95.

Circannual rhythms: endogenous annual clocks in the organization of seasonal processes. 1986. By Eberhard Gwinner. Springer-Verlag, New York. xii + 154 pp., illus. U.S.\$71.

†**Community and evolutionary ecology of North American stream fishes.** 1987. Edited by William J. Matthews and David C. Heins. University of Oklahoma Press, Norman. 384 pp., illus. U.S.\$42.50.

CRC handbook of animal diversity. 1986. By Richard E. Blackwelder and George S. Garoian. CRC Press, Boca Raton, Florida. 568 pp. U.S.\$195 in U.S.A.; U.S.\$225 elsewhere.

Cutthroat: native trout of the west. 1987. By Patrick C. Trotter. Colorado Associated University Press, Boulder. c200 pp., illus. Cloth U.S.\$25; paper U.S.\$12.50.

Ecology and natural history of bees. 1987. By David W. Roubik. Cambridge University Press, New York. c400 pp., illus. + plates. cU.S.\$49.50.

Ecology of Protozoa: the biology of free-living phagotrophic protists. 1987. By Tom Fenchel. Science Technology, Madison, Wisconsin. x + 197 pp., illus. U.S.\$39.

Evolutionary genetics of invertebrate behavior. 1987. Edited by Milton Davis Huettel. Proceedings of a symposium, Gainesville, Florida, 21-24 March, 1984. Plenum, New York. c330 pp. U.S.\$59.50.

The evolution of insect life cycles. 1986. Edited by Fritz Taylor and Richard Karban. Springer-Verlag, New York. x + 287 pp., illus. U.S.\$58.

†**The evolution of vertebrate design.** 1987. By Leonard B. Radinsky. University of Chicago Press, Chicago. c200 pp., illus. Cloth cU.S.\$35; paper cU.S.\$12.95.

†**Field guide to the birds of North America.** 1987. Edited by Shirley L. Scott. Second edition. National Geographic Society, Washington. 464 pp., illus. U.S.\$19.75 plus U.S.\$4.75 postage.

Fire ants and leaf-cutting ants: biology and management. 1986. Edited by Clifford S. Lofgren and Robert K. van der Meer. From a conference, Gainesville, Florida, March, 1985. Westview, Boulder, Colorado. xvi + 435 pp., illus. U.S.\$45.

Foraging behavior. 1987. Edited by Alan C. Kamil, John Krebs, and H. R. Pulliam. Proceedings of a symposium, Providence, Rhode Island, 18-20 June, 1984. Plenum, New York. 670 pp. U.S.\$115.

†**The freshwater fishes of Europe, volume 9: threatened fishes of Europe.** 1987. By Anton Lelek. Edited by the European Committee for the Conservation of Nature and Natural Resources. Aula, Weisbaden, West Germany. 343 pp., illus. DM198 subscription price; DM 236 individual volume.

†**Grand Canyon birds: historical notes, natural history, and ecology.** 1987. By Bryan T. Brown, Steven W. Carothers, and R. Roy Johnson. University of Arizona Press, Tucson. xv + 302 pp., illus. U.S.\$19.95.

The grizzly in the southwest: documentary of an extinction. 1985. By David E. Brown. University of Oklahoma Press, Norman. xx + 274 pp., illus. U.S.\$19.95.

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†**Helping and communal breeding in birds: ecology and evolution.** 1987. By Jerram L. Brown. Princeton University Press, Princeton. xv + 354 pp., illus. Cloth U.S.\$45; paper U.S.\$16.50.

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Insect flight: dispersal and migration. 1986. Edited by W. Danthararaya. From a symposium, Hamburg, August, 1984. Springer-Verlag, New York. x + 289 pp., illus. U.S.\$69.

Insects: their biology and cultural history. 1987. By Bernhard Klausnitzer. Methuen, Toronto. 240 pp., illus. \$63.95.

Island biogeography of mammals. 1986. Edited by L. R. Heaney and B. D. Patterson. Based on a symposium, Edmonton, August, 1985. Linnean Society of London (Published by Academic Press, Orlando). iv + 271 pp., illus. U.S.\$22.50.

Leech biology and behavior, volume 1: anatomy, physiology, and behavior; volume 2: feeding biology, ecology, and systematics; and volume 3: bibliography. 1986. By Roy T. Sawyer. Clarendon (Oxford University Press, New York). 1065 pp., illus. U.S.\$85, U.S.\$75, and U.S.\$40.

†**Mammalian dispersal patterns: the effects of social structure on population genetics.** 1987. Edited by B. Diane Chepko-Sake and Zuleyma Tang Halpin. University of Chicago Press, Chicago. c360 pp., illus. Cloth U.S.\$50; paper U.S.\$19.95.

Mammals in Hawaii: a synopsis and notational bibliography. 1986. By P. Quentin Tomich. Second edition. Bishop Museum Press, Honolulu. viii + 375 pp., illus. U.S.\$42.95.

Mammals of the American north. 1985. By Adrian Forsyth. Camden House (Distributed by Firefly Books, Toronto). 351 pp., illus.

***Manual of nearctic Diptera, volume 2.** 1987. By Research Branch. Agriculture Canada, Ottawa. 64 chapters. \$56.95 in Canada; \$68.35 elsewhere.

Marine gamefish of the middle Atlantic. 1986. By David K. Bulloch. American Littoral Society, Highlands, New Jersey. x + 83 pp., illus. U.S.\$6.

†**The natural history of squirrels.** 1987. By John Gurnell. Facts on File, New York. 232 pp., illus. U.S.\$21.95; Cdn. \$31.95.

Neurobiology and behavior of honeybees. 1987. Edited by R. Menzel and A. Mercer. Springer-Verlag, New York. c350 pp., illus. U.S.\$69.

Our wildlife heritage: a century of use and management. 1987. By the Centennial Wildlife Society of B.C., Victoria. Cloth \$23; paper \$8 plus \$0.75 postage.

Penguins. 1987. By John Sparks and Tony Soper. Facts on File, New York. 240 pp., illus. U.S.\$19.95; Cdn. \$29.95.

Pesticide impact on stream fauna with special reference to macroinvertebrates. 1987. By R. C. Muirhead-Thompson. Cambridge University Press, New York. 288 pp., illus. U.S.\$54.50.

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Rocky Mountain mammals: a handbook of mammals of Rocky Mountain National Park and vicinity. 1987. By David M. Armstrong. Colorado Associated University Press, Boulder. c200 pp., illus. Cloth U.S.\$16.95; paper U.S.\$8.95.

Smith's sea fishes. 1986. Edited by Margaret M. Smith and Philip C. Heemstra. Springer-Verlag, New York. xx + 1047 pp., illus. U.S.\$95.

Songbirds in your garden: how to attract, feed, and enjoy birds in your garden or backyard. 1987. By John K. Terres. Perennial (Distributed by Fitzhenry and Whiteside, Markham, Ontario). 288 pp., illus. \$15.95.

A systematic study of the nearctic larvae of the *Hydropsyche morosa* group (Trichoptera: Hydropsychidae). 1986. By Patricia W. Scheffer and Glenn B. Wiggins. Royal Ontario Museum, Toronto. 94 pp., illus. \$14.25.

Turfgrass insects of the United States and Canada. 1987. By Haruo Tashiro. Comstock (Cornell University Press, Ithaca). xvi + 391 pp., illus. + plates. U.S.\$45.

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†**Waterfowl breeding population surveys, Atlantic Provinces.** 1987. Edited by Anthony J. Erskine. Occasional Paper No. 60. Canadian Wildlife Service, Ottawa. 82 pp., illus.

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Botany

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FRANCIS R. COOK
Editor

TABLE OF CONTENTS (concluded)

status of the Aurora Trout, <i>Salvelinus fontinalis trimagamiensis</i> , a distinct stock endemic to Canada	B. J. PARKER and C. BROUSSEAU	87
status of the Shortnose Cisco, <i>Coregonus reighardi</i> , in Canada	B. J. PARKER	92
status of the Shortjaw Cisco, <i>Coregonus zenithicus</i> , in Canada	J. J. HOUSTON	97
status of the Lake Simcoe Whitefish, <i>Coregonus clupeaformis</i> , in Canada	D. D. EVANS, J. J. HOUSTON and G. N. MEREDITH	103
status of the Squanga Whitefish, <i>Coregonus</i> sp., in the Yukon Territory, Canada	R. A. BODALY, J. W. CLAYTON, and C. C. LINDSEY	114
status of the Deepwater Sculpin <i>Myoxocephalus thompsoni</i> , in Canada	B. J. PARKER	126
statut du Suceur cuivré, <i>Moxostoma hubbsi</i> , au Canada	J.-R. MONGEAU, P. DUMONT, L. CLOUTIER, et A.-M. CLÉMENT	132
updated status of the River Redhorse, <i>Moxostoma carinatum</i> , in Canada	B. J. PARKER	140
updated status of the Silver Shiner, <i>Notropis photogenis</i> , in Canada	M. E. BALDWIN	147
updated status of the Gravel Chub, <i>Hybopsis x-punctata</i> , in Canada	B. J. PARKER, P. MCKEE and R. R. CAMPBELL	158
status of the Redside Dace, <i>Clinostomus elongatus</i> , in Canada	B. J. PARKER, P. MCKEE and R. R. CAMPBELL	163
status of the Banff Longnose Dace, <i>Rhinichthys cataractae smithi</i> , in Canada	JACQUELINE LANTEIGNE	170
Book Reviews		
Ecology: Mammals in North America — Ecological Aspects of Social Evolution in Birds and Mammals — A Coded Workbook of Birds of the World, Volume 1: Non passerines, and Volume 2: Passerines — Handbook of the Birds of Europe, the Middle East, and North Africa: The Birds of the Western Palearctic, Volume IV: Terns to Woodpeckers — Arizona Wetlands and Waterfowl — A World of Watchers — Les oiseaux des régions forestières du nord-est du Gabon, Volume 1: Écologie et comportement des espèces		177
Botany: Orchids of Ontario: An Illustrated Guide — Toronto Islands: Plant Communities and Noteworthy Species — Biology of Lichenized Fungi — The Agaricales (Gilled Fungi) of California — Native and Cultivated Conifers of Northeastern North America: A Guide		183
Environment: A Hierarchical Concept of Ecosystems — Rational for Sampling and Interpretation of Ecological Data in the Assessment of Freshwater Ecosystems — Rivers and Lakes in New Zealand — Bogs of the Northeast — Impact of Acid Rain and Deposition on Aquatic Biological Systems		187
Miscellaneous: The Physiography of Southern Ontario — Biological Museum Methods Volume 1: Vertebrates, and Volume 2: Plants, Invertebrates, and Techniques — Museum Collections: Their Roles and Future in Biological Research		192
New Titles		195
Alfred Bog Fund		201
Advice to Contributors		202
Following date of the previous issue: 101(4): 19 July 1988		

Articles

- Atlantic Leatherback Turtles, *Dermochelys coriacea*, in cold water off Newfoundland and Labrador
GREGORY P. GOFF and JON LIEN
- Effects of the herbicide 2,4,5,-T on the habitat and abundance of breeding birds and small mammals of a conifer clearcut in Nova Scotia
B. FREEDMAN, A. M. POIRIER, R. MORASH, and F. SCOTT
- Migratory patterns of the Wapiti, *Cervus elaphus*, in Banff National Park, Alberta
L. E. MORGANTINI and R. J. HUDSON
- Breeding performance of Black-legged Kitiwakes, *Rissa tridactyla*, at a small, expanding colony in Labrador
T. R. BIRKHEAD and D. N. NETTLESHIP
- Winter and early spring habitat use by Snowshoe Hares, *Lepus americanus*, in south-central Alaska
JAMES G. MACCRACKEN, WILLIAM D. STEIGERS, JR., and PATRICK V. MAYER
- Viability and germination of herbaceous perennial species native to southern Alberta grasslands
E. A. SMRECIU, R. S. CURRAH, and E. TOOP
- Characteristics of Sharp-tailed Grouse, *Tympanuchus phasianellus*, leks in the parklands of Manitoba
RICHARD K. BAYDACK
- The Biological Flora of Canada
8. *Aralia nudicaulis* L., Wild Sarsaparilla
L. B. FLANAGAN and J. F. BAIN

Notes

- Nesting of King Eiders, *Somateria spectabilis*, and Snowy Owls, *Nyctea scandiaca*, near Cape Churchill, Manitoba
TIMOTHY J. MOSER and DONALD H. RUSCH
- A replacement clutch in wild Gyrfalcons, *Falco rusticolus*, in the Northwest Territories
K. G. POOLE
- Southern Bog Lemming, *Synaptomys cooperi*, new to islands in Lake Michigan
CHARLES A. LONG and JOHN EDWARD LONG
- A new Ontario locality record for the crayfish *Orconectes rusticus* from West Duffin Creek, Durham Regional Municipality
STEPHEN H. MAUDE
- Common Raven, *Corax corax*, caching food in snow
LAWRENCE KILHAM
- Yellow-billed Loons, *Gavia adamsii*, nest successfully near Glaucous Gull, *Larus hyperboreus*, nests
MICHAEL R. NORTH and MARK R. RYAN
- Hornseed Buttercup, *Ceratocephalus testiculatus*: a new record for the adventive flora of Saskatchewan
WILLIAM J. CODY
- Moose, *Alces alces*, calf mortality in New Brunswick
ARNOLD H. BOER
- Breeding of the Rock Dove, *Columbia livia*, in January at Edmonton, Alberta
W. BRUCE MCGILLIVRAY
- New Brunswick breeding of Wilson's Phalarope, *Phalaropus tricolor*, confirmed
DONALD F. MCALPINE, MARK PHINNEY and SCOTT MAKEPEACE

News and Comment

- Notice of The Ottawa Field-Naturalists' Club 110th Annual Business Meeting — Call for nominations for 1989 Council — Call for nominations for 1988 Ottawa Field-Naturalists' Club Awards — Baillie Fund grants, 1988 — Baillie Fund grants available for 1989 — Dr. Stuart Houston awarded degree
- Rare and endangered fishes and marine mammals of Canada: COSEWIC fish and marine mammal subcommittee status reports: IV
R. R. CAMPBELL

concluded on inside back cover

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Cover: California Sea Lions, *Zalophus californianus*, at Denman Island (off Vancouver Island), British Columbia. Photographed by Michael A. Bigg. See Status of the California Sea Lion pp. 307-314.

The Canadian Field-Naturalist

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The Wing-moult of Fulmars and Shearwaters (Procellariidae) in Canadian Atlantic Waters.

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Brown, R. G. B. 1988. The wing-moult of fulmars and shearwaters (Procellariidae) in Canadian Atlantic waters. Canadian Field-Naturalist 102(2): 203-208.

The progress of the moult of the primary flight-feathers of non-breeding Northern Fulmars, *Fulmarus glacialis*, and Greater and Sooty Shearwaters, *Puffinus gravis* and *P. griseus*, is described from field observations made in Canadian Atlantic waters, and compared with observation and specimen data from elsewhere in the Atlantic, and from the north-west Pacific and the Canadian High Arctic. Brief notes on wing-moult in Manx, *P. puffinus*, and Cory's shearwaters, *Calonectris diomedea*, are added. The wing-moult of adult Northern Fulmars is apparently completed by April. That of non-breeding birds begins in May or earlier, and is completed by October. The Light and Dark plumage colour-morphs do not differ in this timing. Greater Shearwaters begin to moult as soon as the first birds — presumably post-breeding adults — reach Canadian waters in May, peaks in June on the Grand Banks, and is virtually completed by the end of August. Sooty Shearwaters undergo a wing-moult when they arrive in the north-east Pacific, but do not do so in the North Atlantic. It is suggested that the relatively small Sooty Shearwater population which migrates to the North Atlantic is made up of immature birds.

Key Words: Northern Fulmar, *Fulmarus glacialis*, Greater Shearwater, *Puffinus gravis*, Sooty Shearwater, *Puffinus griseus*, Manx Shearwater, *Puffinus puffinus*, Cory's Shearwater, *Calonectris diomedea*, wing-moult, North Atlantic.

The study of bird moults usually depends on the careful examination of museum specimens. In the case of seabirds, the difficulty of collecting specimens at sea has inevitably restricted our knowledge of the seasonal moult cycles of those species which spend much of their lives away from land. However, one can fill in the gaps, up to a point, by field observation. This paper uses observations to compare and contrast the seasonal moult of the primary flight-feathers in five procellariids in Canadian Atlantic waters (41°-60°N): the Northern Fulmar, *Fulmarus glacialis*, Greater Shearwater, *Puffinus gravis*, and Sooty Shearwater, *P. griseus*, with briefer notes on the Manx Shearwater, *Puffinus puffinus*, and Cory's Shearwater, *Calonectris diomedea*.

Methods

Table 1 summarizes observations that I made in the course of 11 oceanographic cruises off Atlantic Canada between June 1977 and August 1987, and a crossing of the Bay of Fundy on the CN ferry *Bluenose* on 31 July 1985. Additional data were

collected on oceanographic cruises to the Canadian High Arctic (August 1980), off the coast of California (May 1981), and in the Greenland, Barents and Norwegian Seas (March-April 1982: Brown 1984).

For the purposes of this paper, "wing-moult" refers to the moult of the primary flight-feathers. I systematically observed fulmars and shearwaters as they approached the ship for the first time. The gap left by moulted inner primaries conspicuously changes the wing-silhouette, well-shown by Watson (1971: Figure 1) for Greater Shearwaters. The birds were considered to be in "light moult" if only a few feathers were missing, but in "heavy moult" if most of the inner primaries had been lost.

This observation technique undoubtedly underestimates the true numbers of moulting birds. In late June 1969 K. Lambert (*in* Stresemann and Stresemann 1970) examined 77 Greater Shearwaters caught off north-east Newfoundland. Of these, 28 (36.0%) were missing, or were still growing, at least one inner primary feather; these would have been classed "+" (see Table 1) by a field

TABLE 1. Seasonal variations in the occurrence of primary wing-moult (“+”) in Northern Fulmars, *Fulmarus glacialis*, and Greater and Sooty Shearwaters, *Puffinus gravis* and *P. griseus*, observed off Atlantic Canada. n = sample size. For further details, see the text.

	Scotian Shelf*			Grand Banks*			Labrador Sea*			Total		
	+	n	%	+	n	%	+	n	%	+	n	%
Northern Fulmar (Light (LL) colour morph: Fisher 1952):												
May	148	152	97.3	—	—	—	—	—	—	148	152	97.3
June	24	39	61.5	4	8	50.0	—	—	—	28	47	59.6
July	4	13	30.7	—	—	—	327	1132	28.9	331	1145	28.9
August	—	—	—	—	—	—	117	462	25.3	117	462	25.5
October	0	2	0	—	—	—	—	—	—	0	2	0
November	—	—	—	5	217	2.3	7	41	17.1	12	258	4.6
Northern Fulmar (Dark (L + D + DD) colour morphs: Fisher 1952):												
May	4	4	100.0	—	—	—	—	—	—	4	4	100.0
June	—	—	—	1	1	100.0	—	—	—	1	1	100.0
July	0	1	0	—	—	—	28	83	33.7	28	84	33.3
August	—	—	—	—	—	—	15	93	16.1	15	93	16.1
November	—	—	—	0	11	0	0	2	0	0	13	0
Greater Shearwater												
May	55	266	20.7	—	—	—	—	—	—	55	266	20.7
June	35	209	16.7	450	679	66.3	—	—	—	485	888	54.6
July	2	90	2.2	—	—	—	55	751	7.3	57	841	6.8
August	—	—	—	—	—	—	1	173	0.5	1	173	0.5
October	2	287	0.7	—	—	—	—	—	—	2	287	0.7
November	0	217	0	0	4	0	0	3	0	0	224	0
Sooty Shearwater												
May	1	45	2.2	—	—	—	—	—	—	1	45	2.2
June	0	99	0	0	12	0	—	—	—	0	111	0
July	0	11	0	—	—	—	0	296	0	0	307	0
August	—	—	—	0	3	0	0	134	0	0	137	0
October	0	2	0	—	—	—	—	—	—	0	0	2
November	—	—	—	—	—	—	0	1	0	0	1	0

*Scotian Shelf: 41°-48°N, west of 57°W; Grand Banks: 43°-50°N, east of 57°W; Labrador Sea: 50°-60°N, east of 57°W.

Additional data:

Northern Fulmar: In the Greenland, Barents and Norwegian Seas in March–April 1982, I saw no sign of primary wing-moult in a sample of 694 Light, and 384 Dark birds (Brown 1984, and unpublished). I counted 59 “+” Light fulmars (n = 287; 20.5%), and 135 Darks (n = 493; 27.4%), north of 70°N in Baffin Bay and Jones and Lancaster Sounds, in August 1980 (R. G. B. Brown, unpublished). Most of the moulting birds were in Lancaster Sound, west of 80°N. Sooty Shearwater: Off California, on 1–7 May 1981, I counted 12 “+” birds (n = 34; 35.3%) south of 35°N, and 91 (n = 127; 71.6%) north of 39°N (R. G. B. Brown, unpublished).

observer. Of the remainder, five birds (6.5%) with complete sets of old primaries, and six (7.8%) with complete sets of new feathers, would have been correctly noted as not being in wing-moult. But so also would the 38 birds (49.3%) which had complete sets of new, fully-grown inner primaries, but had not yet begun to moult their outer primaries. Moreover, the technique takes no account of birds with apparently unmoulted primaries, but which were moulting their secondary flight-feathers: Table 1). Nonetheless, it

does provide a rough index of the timing of wing-moult in the procellariids, allowing comparisons between different species, seasons and regions.

Results
Northern Fulmar

Large populations of fulmars breed in the North Atlantic and adjacent waters, from the Canadian Arctic to Franz Josef Land, and south to Britain and Brittany (Fisher 1952; Cramp and Simmons 1977). A population of < 100 pairs has bred in

Newfoundland and Labrador since the late 1960s (e.g. Nettleship and Montgomerie 1974), but this cannot account for the very large numbers which occur off eastern Canada throughout the year (Brown et al. 1975). Banding shows that fulmars in the Light, "LL" plumage morph (Fisher 1952) are subadults from colonies in Britain and west Greenland (Salomonsen 1967; Tuck 1971). One would expect birds in the Dark morphs (Fisher's types "L", "D" and "DD") to come from colonies in the eastern Canadian High Arctic, where Dark birds predominate (Fisher 1952), though morphometric data suggest that some also come from the European High Arctic (Brown 1973).

Because of their different breeding areas, Light and Dark fulmars are treated separately in Table 1. However, the percentages of Light and Dark birds in wing-moult off Atlantic Canada do not differ significantly for July or August ($\chi^2 = 0.54$ and 3.12 respectively; $p > .05$, 1 d.f.), the only months in which the Dark samples are large enough for statistical comparison. Nor did the Light and Dark birds that I saw in Baffin Bay/Jones Sound, and in Lancaster Sound, in August 1980 ($\chi^2 = 0.03$ and 3.81 , respectively; $p > .05$, 1 d.f.).

The table also shows that the majority of Light fulmars off Atlantic Canada are in wing-moult in May, but that this proportion declines in the course of the summer and fall ($\chi^2 = 209.05$; $p < 0.001$, 4 d.f.). The timing confirms that these are subadult birds, since breeding fulmars lay in May, and remain at the nest until September (Cramp and Simmons 1977). Subadults in the eastern Atlantic also moult their primaries from May to September (Carrick and Dunnet 1954; Cramp and Simmons 1977). On the other hand, the adults' wing-moult normally starts in late August, though failed breeders may begin in July; it is completed by the end of February. It is possible that the Light birds moulting off Labrador in November (Table 1) are migrant adults from Greenland or Europe.

I saw no sign of wing-moult in either Light or Dark fulmars at the start of the breeding season in the Greenland Sea, in March–April 1982 (Table 1; see also Brown 1984). My observations close to colonies in Jones Sound and northern Baffin Bay (70° – 80° N) in August 1980 (Table 1) showed that only 8.9% of the Light birds, and 1.4% of the Dark were moulting. Both ratios are significantly lower than those for Light and Dark birds off Labrador in August, where virtually all the birds are non-breeders (Table 1; $\chi^2 = 8.221$, $p < 0.01$ and 49.892 , $p < 0.001$ respectively; 1 d.f.). However they are also significantly lower than those in Lancaster

Sound, 28.0% and 31.8%, respectively ($\chi^2 = 8.859$, $p < 0.01$, and 27.140 , $p < 0.001$; 1 d.f.), also in August 1980. Most of these moulting birds were seen in mid August, close to the colony at Hobhouse Inlet, Devon Island and ($74^\circ 27'$ N, $86^\circ 53'$ W; Brown et al. 1975). They may have been failed breeders, or subadults prospecting for nest-sites.

Greater Shearwater

Greater Shearwaters breed mainly on Tristan da Cunha and Gough Islands in the South Atlantic Ocean, and virtually the whole population winters in the North Atlantic. The adults abandon their colonies in April, but the juveniles do not fledge until mid-May or later. The first migrants reach New England and the Grand Banks in late May and early June, and then move north towards southern Greenland, and into the eastern Atlantic. Breeding birds return to Tristan da Cunha at the end of August. However large flocks, presumably of subadults, remain off eastern North America as late as November (Palmer 1962; Salomonsen 1967; Brown et al. 1975; Cramp and Simmons 1977; Powers and Van Os 1979).

Adult Greater Shearwaters retain their old flight-feathers until after they abandon their colonies (Hagen 1952; *see also* Broekhuysen 1948: Figures 5–7). The wing-moult apparently begins as soon as they reach Newfoundland waters. The complete set of primaries is replaced over a period of *ca.* 40 days, and the process is especially rapid among the inner primaries, where up to six feathers may be growing simultaneously (Stresemann and Stresemann 1970). Despite this drastic moult the birds do not become flightless, though they often have difficulty in taking-off.

Moulting Greater Shearwaters have been observed and collected elsewhere in the North Atlantic, from mid-July onwards (Newton 1900; Mayaud 1949–50; Salomonsen 1967, 1979; Stresemann and Stresemann 1970; Gräfe 1973). Salomonsen (1979) saw large numbers off south-west Greenland, still in wing-moult, on 22 August 1954 — at about the time when the first breeding birds return to Tristan da Cunha (Rowan 1952; Cramp and Simmons 1977). One of the five specimens collected in south-west France in November was also still in wing-moult (Mayaud 1949–50). Stresemann and Stresemann (1970) suggest that these late-moulting birds were subadults that migrated north later than the adults. Some Greater Shearwaters — presumably also subadults — moult before they leave the South Atlantic. Watson (1971) observed birds in heavy wing-moult off Tierra del Fuego in January. Birds

collected in Surinam, Trinidad and North Carolina, on their way north in early June, were already in fresh plumage (Watson 1970; Collins and Tikasingh 1974; Mees 1976). The gonads of the North Carolina specimens showed that they had not bred during the previous breeding season (Watson 1970); they were either newly-fledged juveniles, or subadults that had already moulted in the South Atlantic.

Table 1 shows that 20.7% of the Greater Shearwaters, newly arrived on the Scotian Shelf in late May, had already begun to moult their primaries. The proportion of moulting birds dropped to 16.7% in June, and I saw very few after the beginning of July. For all areas combined, the peak of observed wing-moult occurs in June off Atlantic Canada, and it is virtually completed by the beginning of August ($\chi^2 = 838.643$, $p < 0.001$; 5 d.f.). The highest proportion of birds in wing-moult, 66.3%, was on the Grand Banks in late June 1977, almost all of them on the South-east Shoal (ca. 44°N 50°W). This proportion is significantly greater than the May and June ratios on the Scotian Shelf ($\chi^2 = 157.877$ and 156.160 respectively; $p < 0.001$, 1 d.f.). The importance of the Shoal is underlined by the large number of shearwaters that were in "heavy moult": 414 out of the 450 birds in wing-moult (92.0%). This is significantly higher than the ratio on the Scotian Shelf in May (15 out of 35 (27.3%) $\chi^2 = 155.586$, $p < 0.001$; 1 d.f.) and in June (13/26 (37.1%); $p < 0.001$, by Fisher's Exact Method).

Sooty Shearwater

Sooty Shearwaters breed in the Falkland Islands, southern Chile, New Zealand and Australia. Most of them winter in the North Pacific, but smaller numbers migrate to the North Atlantic, and others remain in the southern hemisphere. The adults leave their colonies early in April, and the juveniles fledge at the end of that month. Sooty Shearwaters arrive in the northern hemisphere at the beginning of May or even earlier. In the North Atlantic, they come to New England and Newfoundland first; most of the birds then cross to European waters in August. (Palmer 1962; Phillips 1963; Richdale 1963; Jehl 1974; Brown et al. 1975; Cramp and Simmons 1977; Warham et al. 1982).

Little is known of their wing-moult cycle. In the Pacific, the breeding adults apparently moult their primaries in the northern hemisphere in May–August. However, birds in moult, presumably subadults, have been collected off Chile and California as early as February–March (Loomis 1918; Palmer 1962; Cramp and Simmons 1977). At

the beginning of May 1981, I found (Table 1) that Sooty Shearwaters, newly arrived off California, had already begun a rapid moult of their primaries. Seven of the 12 birds that I saw in wing-moult south of 35°N (58.3%), and 88 out of 91 (96.7%) north of 39°N, were in "heavy moult". In Hecate Strait, British Columbia (ca. 53°N), Sooty Shearwaters began to moult as soon as they arrived, at the end of April 1985; ca. 90% of the birds were in wing-moult by the end of May, and the beaches were littered with their discarded flight feathers (A. J. Gaston, Canadian Wildlife Service, Ottawa; personal communication).

However, the situation in the North Atlantic is very different (Table 1). Sooty Shearwaters in eastern Canadian waters almost always have complete sets of flight feathers, new in appearance. These are in sharp contrast to the incomplete and obviously worn primaries of the Greater Shearwaters seen at the same time. The sole exception was a bird seen on 30 May 1979, that had lost a single primary feather from one wing. Nonetheless, some wing-moult does occur in the North Atlantic. A bird collected off southwestern France in November was moulting its primaries — but 13 others, collected there between August and January, had complete sets of new flight-feathers (Mayaud 1949–50).

Other shearwaters

Two other shearwaters occur regularly off eastern Canada. The Atlantic subspecies of the Manx Shearwater, *Puffinus puffinus puffinus*, breeds mainly in the north-east Atlantic, though it has also established a small colony in Newfoundland (Cramp and Simmons 1977; Storey and Lien 1985). It winters in the South Atlantic and moults its flight-feathers there, between September and February (Cramp and Simmons 1977). No wing-moult was apparent in eight birds that I saw off Atlantic Canada in June–July.

Cory's Shearwater, *Calonectris diomedea*, also breeds in the eastern North Atlantic, and winters in the South Atlantic. It is believed to moult its primaries in its winter quarters, probably between September and March (Cramp and Simmons 1977). I observed 52 birds on the Scotian Shelf in late June 1980; none showed any sign of wing-moult. However, one bird seen there on 31 July 1985, and two others on 29 August 1979, were all moulting their primaries — in "heavy moult", in the case of the August birds. To judge from the timing of the species' breeding cycle, all of these must have been non-breeding birds (Cramp and Simmons 1977). It therefore seems that at least part of the immature population undergoes wing-

moult before the fall migration to the southern hemisphere.

Discussion

The data presented here suggest three seasonal patterns of primary moult among procellariids off Atlantic Canada. Non-breeding Northern Fulmars have a relatively protracted moult which extends from May to September. The Greater Shearwater moult is a more rapid process, peaking in June. The actual wing-moult season extends from May to July — to August, off Greenland — but this is probably the sum of a series of rapid moults, as waves of late migrants reach the North Atlantic (Stresemann and Stresemann 1970). The Sooty Shearwater has a rapid moult in May and June in the North Pacific but not in the Atlantic, where very few birds moult at all.

Shearwaters are birds with long, thin wings and a fast, gliding flight with little wing-flapping. The birds' high wing-loadings, and also their long wing-spans, make it difficult for them to take off from flat surfaces on land, and from the sea when it is calm (e.g. Broekhuysen 1948; Warham 1977; Warham et al. 1982; R. G. B. Brown, personal observations). Warham (1977) has calculated that the Sooty Shearwater has a wing-loading of 1.13 g of body weight/cm of wing area — a high figure for a procellariiform. No calculation has been made for the Greater Shearwater but, as its wings are a little broader (Cramp and Simmons 1977), the ratio is probably a little lower. Moulting the inner primaries reduces the wing area, and thus increases the wing-loading. I estimate from Watson's (1971: Figure 1) photographs that the area of an extended Greater Shearwater wing in "heavy moult" is 10% less than one with a full set of primaries.

Seabirds that migrate across the Equator must cross the Doldrums — the zone of equatorial calms — in both the Atlantic and Pacific (e.g. Murphy 1936). There are obvious advantages in doing so with the minimum possible wing-loading ratio — that is, with a full set of flight-feathers. Wing-moult, in other words, must either be completed before the birds leave the breeding area, or postponed until they arrive in their winter quarters. The data presented by Stresemann and Stresemann (1970) and in the present paper strongly suggest that breeding adult Greater Shearwaters postpone their wing-moult until after their northward migration. To moult in the South Atlantic before the colonies are abandoned would presumably reduce the birds' foraging efficiency and ability to take off from land; to moult after breeding but before migrating would expose them

to the onset of the austral winter. A postponement, on the other hand, would allow them to arrive off Newfoundland just as the boreal summer begins, when potential prey are becoming increasingly abundant. Subadult Greater Shearwaters, without the constraints imposed by breeding, could moult their flight-feathers before they migrate north, and it is clear that some of them do so (Watson 1971). However, the moulting birds observed and collected in the north-west Atlantic in July and August were almost certainly also subadults (Salomonsen 1967, 1979; Stresemann and Stresemann 1970; Gräfe 1973). It is not clear why they postponed their moult until they reached the northern hemisphere.

The contrast with Sooty Shearwaters is interesting. The Californian data suggest that adult sooties, like adult Greater Shearwaters in the Atlantic, moult their flight feathers as soon as they reach their winter quarters. The fact that virtually no wing-moult takes place in the North Atlantic seems to indicate that the Sooty Shearwaters that "winter" there are either newly-fledged juveniles, or subadults that have already completed their moult before the start of migration. If so, then the relatively small Sooty Shearwater population which winters in the North Atlantic may well consist almost entirely of young birds. In support of this, a juvenile banded in the Falklands was recovered on its way north, off Barbados, on 1 June (Woods 1975).

Finally, moulting is energetically expensive (e.g. Wiens and Scott 1975), and it is not surprising that it should take place in areas where food is locally abundant. The Sooty Shearwaters moulting in the north-east Pacific feed on the abundant Northern Anchovy, *Engraulis mordax* (Wiens and Scott 1975). Capelin, *Mallotus villosus*, are an important food for Greater Shearwaters in the North Atlantic (Brown et al. 1981). One of the Newfoundland Capelin stocks migrates to the South-east Shoal in June to spawn (Jangaard 1974; Carscadden 1984), just at the time when the first migrants arrive on the Grand Banks (see above). The areas off southern Greenland, where Greater Shearwaters moult later in the summer (e.g. Gräfe 1973; Salomonsen 1979), also support a large Capelin population (Jangaard 1974).

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The Parasitic Dodders (*Cuscuta*: Cuscutaceae) in Ontario

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Crins, William J., and Bruce A. Ford. 1988. The parasitic dodders (*Cuscuta*: Cuscutaceae) in Ontario. *Canadian Field-Naturalist* 102(2): 209–215.

Six species of the parasitic genus *Cuscuta* have been found in Ontario. Four of these are rare native species, one is an adventive Eurasian weed of legume crops, and one is common in natural habitats. Two species (*C. cephalanthi* and *C. coryli*) are reported from Ontario for the first time. Several errors in the literature concerning reports of the occurrence of species in Ontario are corrected. Habitat preferences and host relationships of all species are summarized, and a key to the species occurring in Ontario is presented.

Key Words: *Cuscuta*, dodder, Ontario, distribution, ecology, parasite-host relationships, rare plants.

The parasitic dodders (*Cuscuta*: Cuscutaceae) are distributed throughout the tropical and temperate regions of the world. The genus is composed of approximately 150 species (Yuncker 1932, 1965). It is generally accepted that it is related to, and derived from, the Convolvulaceae, and is treated as a monogeneric subfamily of the Convolvulaceae, or as a distinct family (Cronquist 1981; Jones and Luchsinger 1986; Smith 1977). The most recent comprehensive revision of the North American taxa was prepared by Yuncker (1965), who had also monographed the genus on a world-wide scale (Yuncker 1932). Most regional floras prepared since Yuncker's treatments have relied heavily on his keys, descriptions, and distribution summaries (Fernald 1950; Gleason 1952; Scoggan 1979).

During the preparation of distribution maps for the *Atlas of the Rare Vascular Plants of Ontario* (Crins and Ford 1987), we compiled distributional and ecological data for the six species of *Cuscuta* that occur in the province. Regional floras covering Ontario often include much larger geographical areas (eastern North America: Fernald 1950 and Gleason 1952; Canada: Scoggan 1979), and as a result, more species of *Cuscuta* than occur in the province are included in the keys. The massive revisions of Yuncker (1932, 1965) include so many taxa that the keys are difficult to use. Some of the difficulty in species recognition relates to the small size of the flowers, subtle differences in shape, size, and number of floral parts, and the absence of vegetative characters. The aims of this paper are to 1) correct erroneous literature reports, 2) provide a key, 3) document the distributions, and 4) summarize the host relationships and ecological preferences of the species of *Cuscuta*

occurring in Ontario. We have examined specimens contained in the following herbaria: APM, CAN, DAO, HAM, LKHD, MT, MTMG, OAC, QK, TRT, TRTE, UWO, WOCB, Rondeau Provincial Park, and the personal herbaria of P.W. Ball, D.F. Brunton, and P.F. Maycock (acronyms according to Holmgren et al. 1981).

Taxonomy, Distribution, and Ecology

Six species of *Cuscuta* have been confirmed as having occurred in Ontario: *C. campestris* Yuncker, *C. cephalanthi* Engelm., *C. coryli* Engelm., *C. epithymum* (Linnaeus) Linnaeus, *C. gronovii* Willdenow, and *C. polygonorum* Engelm. Two of these (*C. cephalanthi* and *C. coryli*) are newly recorded from Ontario (cf. Scoggan 1979). *Cuscuta epithymum* is a naturalized Eurasian weed (cf. Feinbrun 1972). *Cuscuta epilinum* has been reported by Scoggan (1979) from Galt in the Regional Municipality of Waterloo, but we have not seen any authentic material of this species from the province. In addition, *C. indecora* Choisy has been cultivated experimentally, but it has never spread from cultivation (relevant specimens in DAO). *Cuscuta compacta* Jussieu has been reported as a hypothetical member of Ontario's flora (Scoggan 1979), but there are no specimens to support the occurrence of this distinctive species in the province. Fernald (1950), Gillett and White (1978), Scoggan (1979), and Stroud (1941) also reported *C. pentagona* Engelm. from the province, but its occurrence has not been confirmed. These erroneous reports stem from two sources — nomenclatural confusion (Fernald 1950; Stroud 1941) and conservative species concepts (Gillett and White 1978; Scoggan 1979). In the past, *C.*

campestris has been treated as a variety of *C. pentagona* (var. *calycina* Engelm.) by some authors. It has also gone under the name *C. arvensis* Beyrich. Further confusion arose because *C. arvensis* has also been applied to *C. pentagona*. We prefer to follow Yuncker (1965), who recognized *C. campestris* and *C. pentagona* as distinct species.

Cuscuta campestris Yuncker

This species has been recognized for some time, but it was not until 1932 that Yuncker provided the name now widely used for it. As is evident from the previous discussion, much nomenclatural confusion has been associated with this plant, in spite of Yuncker's (1932, 1965) clarifications. Crins and Ford (1987) have prepared a map of the distribution of this species in Ontario. *Cuscuta campestris* is scattered throughout the southern part of the province, from Essex County in the west to the Regional Municipality of Ottawa-Carleton and Glengarry County in the east. This species does not occur on the Precambrian Shield. It appears to have been an important parasitic weed of cultivated crops, especially legumes such as red clover (*Trifolium pratense* L.) and alfalfa (*Medicago sativa* L.), prior to the 1950s (Groh 1942), but very few recent collections have been made. Perhaps it is unable to tolerate the use of modern pesticides and other agricultural practices. Although *C. campestris* exhibits a weedy tendency, it has also been found in natural moist habitats such as marshes, exposed pond bottoms, and creek banks. In Ontario *C. campestris* has been recorded as a parasite on *Agrostis*, *Ambrosia*, *Aster*, *Bidens*, *Circaea*, *Daucus*, *Linum*, *Malva*, *Medicago*, *Melilotus*, *Polygonum*, and *Trifolium*.

Cuscuta cephalanthi Yuncker

Cuscuta cephalanthi, the Buttonbush Dodder, is newly reported from Ontario (cf. Scoggan 1979). It is known from six widely scattered localities in southern and western Ontario (Crins and Ford 1987), but its distribution pattern suggests that it should be looked for in natural habitats elsewhere in the southern parts of the province, and the southwestern part of Rainy River District. It has been found in moist meadows, marshy creek edges, on the fringes of desiccating ponds, in wet prairies, and in floodplain woods. Species of *Aster*, *Decodon*, *Lythrum*, *Polygonum*, *Pycnanthemum*, and *Solidago* have served as hosts for this species in Ontario.

This species is most similar to the common and widespread *C. gronovii*, but it can be distinguished from the latter by its predominantly 4-merous

flowers and persistent corolla on the fruit. A peculiar feature that has not been seen in any other Ontario species is the tendency of the capsule to be one-seeded (as opposed to the two to four-seeded capsules of other species). These features are distinctive and diagnostic.

Cuscuta coryli Engelm.

This species is also rare in Ontario, and is restricted to extreme southwestern Ontario (Crins and Ford 1987). Although it was first collected in Lambton County in 1908, it was misidentified, and as a result, it has gone unreported in Ontario until now. In recent years, it has been found in several locations in Essex and Kent counties. Habitat data are limited, but it appears to grow in moist, open tall-grass prairie and meadows, sometimes at the edge of oak woods. It is known to parasitize species of *Aster*, *Helianthus*, *Monarda*, *Rubus*, and *Solidago* in Ontario.

This species is distinguished by its acuminate, slightly incurved, papillate corolla lobes and long pedicels (see Figure 3c).

Cuscuta epithymum (Linnaeus) Linnaeus

This Eurasian species was a serious pest of alfalfa (*Medicago sativa*) at the turn of the century (Groh 1942). Figure 1 presents the former distribution of *C. epithymum* in Ontario. No recent collections have been made in Ontario.

The Eurasian species can easily be distinguished from the native dodders occurring in Ontario on the basis of stigma morphology. *Cuscuta epithymum* has linear stigmas which are hardly distinguishable from the styles. In all of the native species, the stigmas are capitate, so that there is an evident dilation or bulbous appendage at the apex of each style.

Cuscuta epithymum has also been called *C. trifolii* Bab. (Feinbrun 1972).

Cuscuta gronovii Willdenow

Cuscuta gronovii is the only species of dodder in Ontario that can be considered to be common. It is widespread throughout southern Ontario, and is found infrequently on the Precambrian Shield in central and western Ontario (Figure 2). Although we have not seen a specimen from Manitoulin Island, we have no reason to doubt the identity of the dodder reported from that area by Morton and Venn (1984). It occurs in moist habitats such as the edges of shorelines, river floodplains and banks, swamps (coniferous and deciduous), meadows, thickets, and ditches. Occasionally, it invades drier disturbed sites or cultivated areas. It has also been collected in rose gardens, along fence rows, in tobacco fields, and on railway beds. The wide array



FIGURE 1. Distribution of *Cuscuta epithymum* (L.) L. in Ontario.

of genera which have been parasitized by *C. gronovii* in Ontario include *Agrostis*, *Amaranthus*, *Amphicarpaea*, *Aster*, *Betula*, *Bidens*, *Boehmeria*, *Brassica*, *Carex*, *Cephalanthus*, *Chelone*, *Cirsium*, *Cornus*, *Daucus*, *Decodon*, *Epilobium*, *Eupatorium*, *Glyceria*, *Helianthus*, *Impatiens*, *Laportea*, *Lobelia*, *Lysimachia*, *Nicotiana*, *Parthenocissus*, *Poa*, *Polygonum*, *Salix*, *Sium*, *Solanum*, *Solidago*, *Triadenum*, *Typha*, *Urtica*, *Verbena*, and *Vitis*.

The capsules of *C. gronovii* are ovoid to distinctly conical in shape, and are quite variable in size. The seeds are generally less than 2 mm long. A few plants have been seen with some seeds over 2 mm long. Plants with seeds 2.0–2.8 mm long have been segregated as *C. umbrosa* Hooker (= *C. curta* Rydberg, *C. megalocarpa* Rydberg) by Yuncker (1965). However, in those Ontario specimens with a few large seeds, the majority of the seeds are less than 2 mm long. We prefer to include such plants under *C. gronovii*.

Cuscuta polygonorum Engelmann

This species is known from a single location in Ontario (Point Pelee, Essex County: Crins and Ford 1987). No habitat data are available, but the plant was parasitizing an introduced species of *Ipomoea*. It is similar to the western *C. indecora*, which has been cultivated in Ontario, but differs in its 4-merous flowers and rudimentary infrastaminal scales.

Key to the *Cuscuta* spp. Occurring in Ontario

The following key focuses on the predominant condition found in each taxon. It has benefited greatly from the keys and descriptions of Yuncker (1965) and Feinbrun (1972), but has been modified and simplified to accommodate the Ontario plants. It is probably applicable in other parts of eastern Canada, but does not include species found further south or west. It should be noted that features such as the number of perianth lobes, infrastaminal scale shape and size, and the number of seeds per

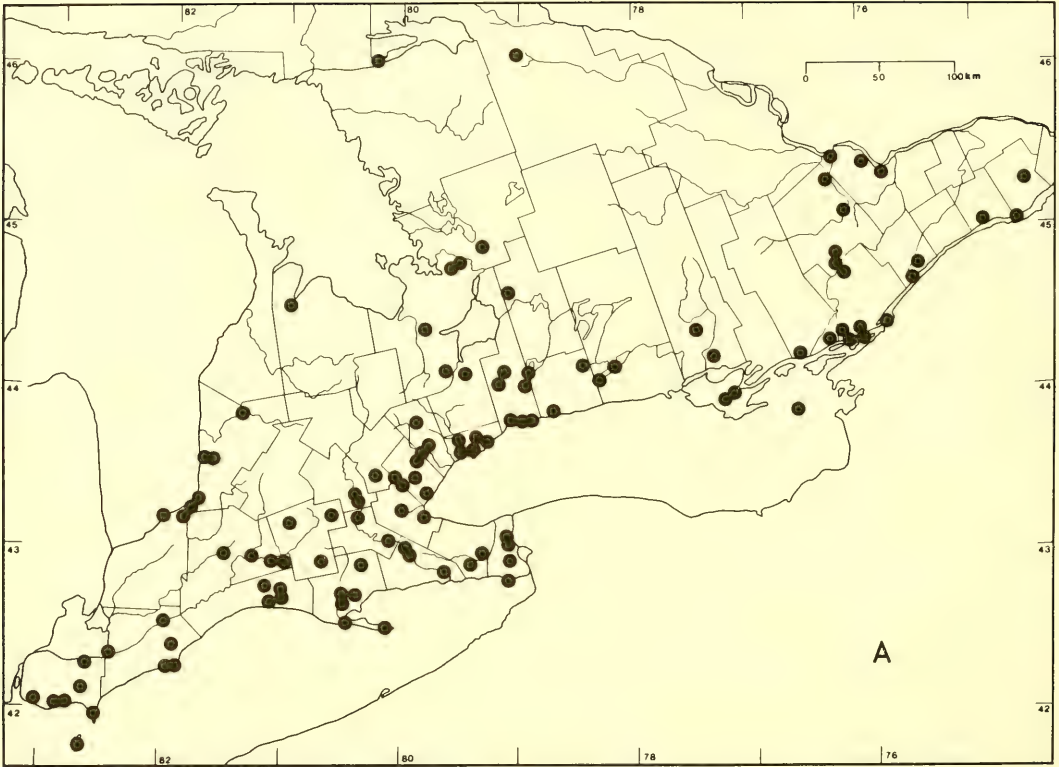


FIGURE 2a. Distribution of *Cuscuta gronovii* Willd. in southern Ontario. Open symbol (Manitoulin Island, upper left corner) represents literature report for which no specimen was seen.

capsule may vary among plants or within a plant. Thus, it is recommended that at least five flowers be examined to determine the average state for each character on a given plant.

Two characters commonly used in *Cuscuta* taxonomy are infrastaminal (= antestaminal) scale morphology and capsule morphology. These characters are often inadequately defined, and can lead to confusion unless they are properly understood. Infrastaminal scales (Figure 3c) are dilations of the lowermost part of the filament and are found opposite each stamen, near the base of the corolla. The size and shape of these scales are considered to be diagnostic in some species. The term “depressed-globose” is used to describe capsule morphology of certain species in the following key. These capsules are often wider than tall, and the apical pore is sunken relative to the rest of the capsule (Figure 3b). Figure 3a illustrates the ovoid capsule of *C. gronovii* for comparative purposes.

- 1. Stigmas linear; capsules circumsissile near base; corolla lobes acute to acuminate; seeds less than 1.3 mm long; stem much branched; calyx lobes often tinged with reddish; parasitic on legumes *epithymum*
- 1. Stigmas capitate; capsules dehiscent irregularly; corolla lobes obtuse or acute to acuminate; seeds more than 1.3 mm long; calyx lobes yellowish or white 2
- 2. Flowers normally 4-merous; corolla lobes erect (occasionally patent); capsules depressed-globose (ovoid if 1-seeded) 3
- 3. Calyx shorter than corolla tube; corolla and calyx lobes obtuse; corolla detaching at base and forming cap over capsule at maturity; infrastaminal scales fringed at apex; pedicels shorter than flower; capsule sometimes 1-seeded *cephalanthi*
- 3. Calyx equalling or exceeding corolla tube; corolla lobes acute to acuminate; infrastaminal scales entire, erose, or bifid at apex 4



FIGURE 2b. Distribution of *Cuscuta gronovii* Willd. in northern Ontario.

- 4. Calyx lobes acute, divided to the base and sometimes with a more or less evident ridge or keel down the center; corolla lobes acuminate, often slightly incurved at apex, distinctly papillate; corolla detaching at base and forming cap over capsule at maturity; pedicels often as long or longer than flower *coryli*
- 4. Calyx lobes obtuse, not divided to the base, unkeeled; corolla lobes acute, flat, smooth; corolla persistent around base of capsule; pedicels shorter than flowers *polygonorum*
- 2. Flowers normally 5-merous; corolla lobes patent to deflexed 5
- 5. Capsule depressed-globose; calyx equalling or exceeding corolla tube; corolla lobes acute *campestris*
- 5. Capsule ovoid to conical; calyx much shorter than corolla tube; corolla lobes obtuse *gronovii*

Summary

Five native species and one adventive species of *Cuscuta* have been found in Ontario. Four of these

(*C. campestris*, *C. cephalanthi*, *C. coryli*, and *C. polygonorum*) are rare in the province (Crins and Ford 1987). Very little collecting of dodders has occurred recently (within the past 20 years), and it seems quite likely that new stations of some of the rare species will be discovered, especially in the southwestern (Carolinian) and extreme western (Rainy River District) parts of the province. It is also possible that additional species will be discovered. For example, *C. indecora* and *C. glomerata* Choisy have been found in Michigan (Yuncker 1921), *C. pentagona* and *C. suaveolens* Seringe have been found in Ohio (Cooperrider, unpublished data), and *C. umbrosa* has been found in Manitoba (Scoggan 1979).

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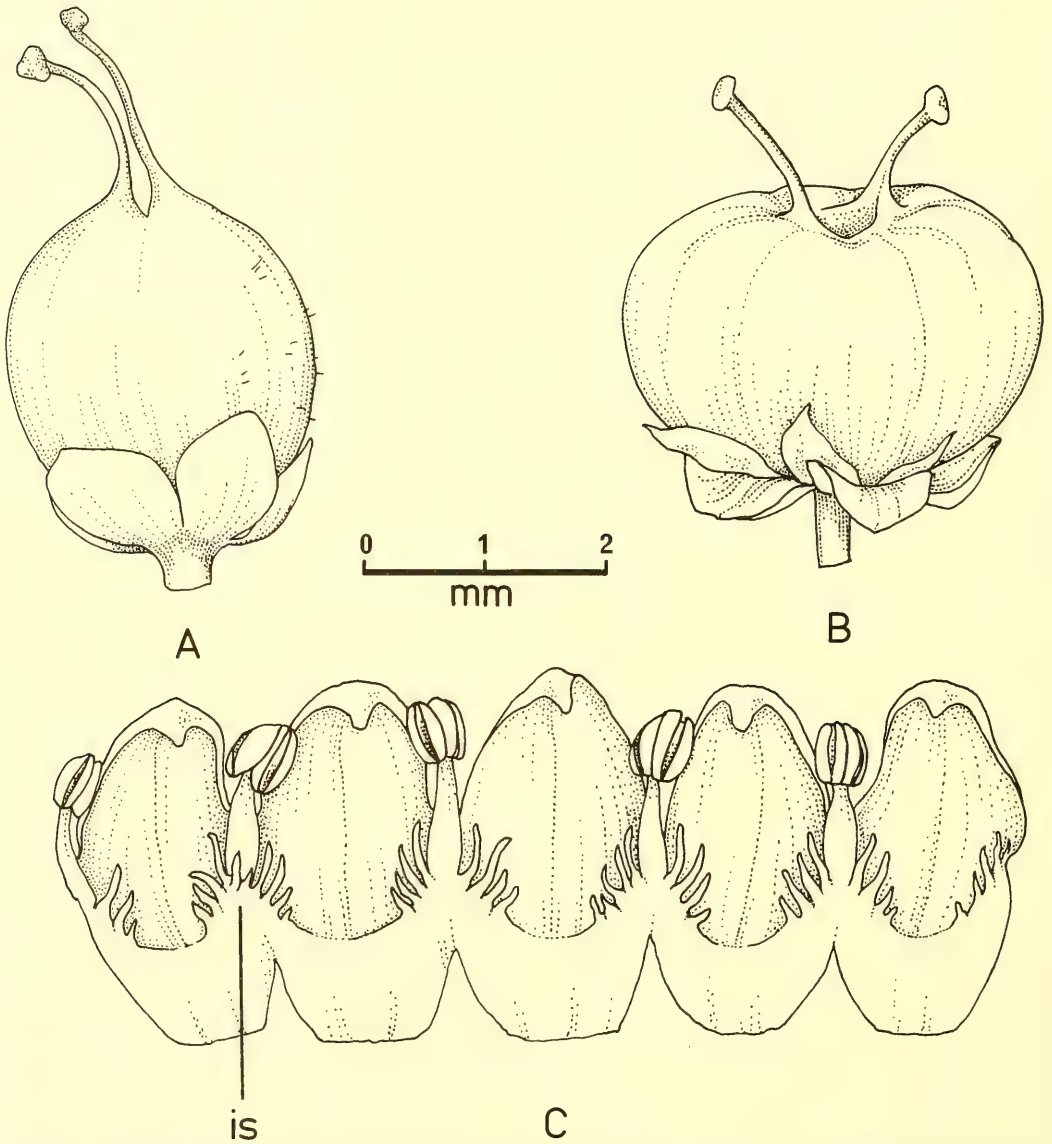


FIGURE 3. Morphological features of *Cuscuta* flowers and fruits: a) ovoid capsule of *C. gronovii* Willd.; b) depressed-globose capsule of *C. campestris* Yunker, also showing remnants of acute corolla lobes at its base; c) opened 5-merous corolla of *C. coryli* Engelm., indicating location of infrastaminal scales (is). (Drawn from Ontario material by Lesley Bohm).

us with the excellent drawings in Figure 3. We also thank Peter Ball, Erindale Campus, Mississauga, for tolerating and encouraging our sojourns away from *Carex* systematics.

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Effect of Lichen and In Vitro Methodology on Digestibility of Winter Deer Diets in Maine

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In vitro fermentations using domestic cow and deer inocula were conducted to examine digestibilities of lichens and coniferous forages that are consumed by White-Tailed Deer (*Odocoileus virginianus*) in winter in Maine. Expected in vivo (converted from in vitro) dry matter digestibilities (DMD) of diets calculated from single species digestions were compared to 1) in vivo DMD of mixed diets and 2) apparent digestibilities that were obtained from previous research on captive White-Tailed Deer. Fermentations using cow inoculum were significantly lower than those using deer inoculum. No lichen-induced synergisms were found using either inocula. Apparent digestibilities from earlier studies were significantly higher than all in vitro or in vivo estimates of digestibility. Results suggest that analytical techniques and inocula source can underestimate digestibilities of some winter forages.

Key Words: digestibility, lichens, Maine, White-Tailed Deer, *Odocoileus virginianus*, winter diets.

Individual forages contribute different components to the nutritional quality of White-Tailed Deer (*Odocoileus virginianus*) diets in winter (Short 1971; Ullrey et al. 1971; Mautz et al. 1976). Browse species, which can constitute the bulk of winter diets, generally are of low digestibility (Mautz et al. 1976). Certain combinations of winter forages may be crucial to deer survival during extended periods of deep snow and low temperatures. Some winter forages may contain high levels of protein and/or carbohydrate that could increase digestibility of winter diets (Ullrey et al. 1971). Addition of cornstarch to in vitro digestions increased digestibility of five winter forages (McCullough 1979), indicating synergisms in the fermentation process.

Rochelle (1980) noted that a fruticose lichen, *Alectoria sarmentosa*, increased digestibility of diets consumed by Black-Tailed Deer (*O. hemionus columbianus*). Mixed diets that contained various proportions of lichen increased diet DMD by 5-15% above levels expected from combined digestibilities of component species. That suggested that lichen was acting as a carbohydrate source (Scotter 1965), which would enable deer to use recycled urea more efficiently (Orskov 1982:28). However, Person (1975) was unable to document such synergistic effects using in vitro digestions.

Published in vitro DMD of fruticose lichens show high variability. Hanley and McKendrick (1983) found extremely low digestibilities (21.1%)

for *Usnea* spp., whereas Rochelle (1980) found high digestibilities (78.1%) for *Alectoria sarmentosa*. Both arboreal lichens are taxonomically similar (Family Usneacea) (Ahmadjian and Hale 1973) and are preferred by deer (Rochelle 1980; Hanley and McKendrick 1983; Hodgman and Bowyer 1985).

During winter in parts of Maine, White-Tailed Deer can have high proportions of conifers in their diet (Crawford 1982; Ludewig and Bowyer 1985); fruticose lichens also are consumed when available (Hodgman and Bowyer 1985). In our study, diets containing lichens (*Usnea* spp. and *Evernia mesomorpha*) and coniferous forages were digested in vitro to determine: 1) possible synergistic effects among forages, and 2) effects of inocula source on digestibility estimates. Also, average in vivo DMD values (converted from in vitro digestions) were compared to average apparent digestibilities of diets determined from captive White-Tailed Deer (Jenks 1986) to determine the utility of in vitro estimates in predicting in situ digestibilities.

Methods

White Cedar (*Thuja occidentalis*), Eastern Hemlock (*Tsuga canadensis*), Balsam Fir (*Abies balsamea*), mixed spruce (*Picea* spp.), and a naturally-occurring combination of fruticose lichens (*Usnea* spp. and *Evernia mesomorpha*) were collected in January 1985 in northern Maine (45°57'N; 69°10'W). Samples were frozen until prepared for digestion trials.

Four diets were formulated that contained equal portions of the four conifers and a lichen component of 0, 5, 15, and 25%. Forage samples were dried to constant weight at 50°C and ground in a Wiley Mill through a #20 mesh screen. Duplicate 0.3 g samples of each individual forage and the four experimental diets were digested using the two-stage digestion technique of Tilley and Terry (1963), as modified by Palmer et al. (1976) for use with deer forages. If duplicate samples differed by > 5% they were discarded. Forage standards that were obtained from W. L. Palmer (Pennsylvania State University) were digested to calculate specific regression formulas for each trial for conversion of in vitro to in vivo digestibilities (Palmer and Cowan 1980). Trial specific regressions were used to control between trial error (Milchunas and Baker 1982).

Rumen inocula were obtained from a fistulated cow (16% protein diet) and three White-Tailed Deer that were maintained on the four conifers and lichen for 25 days and died during or after digestion trials (Jenks 1986). Rumen contents were squeezed through two layers of cheese cloth. Availability of deer inoculum was fortuitous and therefore limited; only lichen diets and three of the four conifer species could be digested with deer inoculum.

Following Westoby (1974), expected dietary digestibilities were calculated from single species digestions (in vivo converted DMD using deer and cow inoculum) and were compared using t-tests (Sokal and Rohlf 1981). Digestibilities of single species summations (t-tests) and mixed diets (ANOVA) also were compared to diet apparent digestibilities (Robbins 1983: 279). Apparent digestibilities of the four diets were determined in four trials (four deer/trial) by randomly assigning deer to diets for a 9–14 day pretrial period after which all feces were collected for 5–7 days (Jenks 1986).

Results

Converted in vivo DMD averaged 36.6% (SD = 8.41) for all plant species digested with cow inoculum (Table 1). In vivo DMD of mixed diets was not different from single species summations of DMD ($t = 0.048$, $df = 31$, $p = 0.96$) [Table 2]. Therefore, no synergisms in the mixed diets were observed with cow inoculum.

Converted in vivo DMD for forages digested with deer inoculum averaged 50.3% (SD = 9.94) [Table 1]. The four diets and a sample of hemlock were not digested with deer inoculum. Hemlock digestibility was estimated by regressing the 2 estimates of in vivo DMD ($x = \text{cow}$; $y = \text{deer}$

TABLE 1. Mean in vitro and in vivo^a dry matter digestibilities (DMD) of plant species digested with cow and deer inoculum.

Species	Cow Inoculum		Deer Inoculum	
	In Vitro	In Vivo	In Vitro	In Vivo
<i>Abies balsamea</i>	37.5	33.4	33.9	46.2
SD	(0.19)	(1.91)	—	—
N ^b	3	3	1	1
<i>Picea</i> spp.	27.7	24.5	34.6	41.4
SD	(0.94)	(1.82)	—	—
N	3	3	1	1
<i>Thuja occidentalis</i>	47.1	43.3	37.9	47.4
SD	(1.18)	(2.34)	—	—
N	3	3	1	1
<i>Tsuga canadensis</i>	48.8	45.6	—	49.0 ^c
SD	(0.79)	(1.66)	—	—
N	3	3	—	1
<i>Usnea</i> spp. / <i>Evernia mesomorpha</i>	39.1	36.1	43.9	67.3
SD	(6.76)	(5.83)	(8.36)	(2.33)
N	9	9	2	2

^aConverted from in vitro estimates using procedure of Palmer and Cowan (1980).

^bAverage of duplicate estimates not exceeding a difference of 5%.

^cEstimated using regression analysis (see text).

TABLE 2. Mean in vivo dry matter digestibilities (DMD)^a and apparent digestibilities for diets containing a lichen component.

Percent Lichen	Dietary digestibility			
	Single Species Summations		Mixed Diets	
	Cow Inoculum	Deer Inoculum	Cow Inoculum	Apparent ^b Digestibility
0	36.7	46.0	35.4	54.3
SD	—	—	1.6	5.8
N	1	1	6	3
5	36.7	47.0	37.0	55.0
SD	—	—	1.7	3.0
N	1	1	8	3
15	36.6	49.2	35.6	56.2
SD	—	—	2.4	5.9
N	1	1	7	4
25	36.6	51.3	37.2	57.5
SD	—	—	4.6	1.0
N	1	1	8	4

^aConverted from in vitro digestibility following Palmer and Cowan (1980).

^bDetermined from digestibility trials (Jenks 1986).

inocula) for the remaining three conifers and predicting in vivo DMD for hemlock with its in vivo estimate (x) and the regression formula ($Y = 33.595 + 0.338X$; $r^2 = 0.93$) [Table 1]. Expected in vivo DMD estimates for diets were determined with those single species estimates of digestibility (Table 2).

A two-factor analysis of variance comparing converted (cow inoculum) and apparent digestibility for the four lichen diets (method $\times$ percent dietary lichen) was significant ($F_{4,38} = 17.76$, $p < 0.001$) [Table 2]. No differences were found among diets containing a lichen component ($F_{3,38} = 0.19$, $p > 0.10$); however, apparent digestibilities were significantly higher than converted in vivo DMD estimates (cow inoculum ($F_{1,38} = 70.49$, $p < 0.001$). Expected in vivo DMD estimates using deer inoculum also were higher than those determined with cow inoculum ($t = 9.92$, $df = 6$, $p < 0.001$) but lower than apparent digestibilities from digestion trials ($t = 3.51$, $df = 16$, $p = 0.003$) [Table 2; Figure 1].

Converted in vivo DMD of lichen in deer inoculum (67.3%) [Table 1] was nearly twice that of cow inoculum estimates (36.1%). As a result, any increase in lichen proportion in simulated deer diets increased expected dietary DMD (Figure 1). The same effect was not noted for cow inoculum because DMD estimates of lichen were similar to those of conifers (Table 1).

Statistical test scores presented here do not agree with those in Jenks (1986). Errors in computation did not affect interpretation and were corrected during editorial review.

Discussion

Thomas and Kroeger (1981) and Thomas et al. (1984) suggested that low in vitro DMD of lichens commonly ingested by Caribou (*Rangifer tarandus*) resulted because of low nitrogen or temporal conditions that limited digestibility. A 60 hr fermentation stage increased digestibility of lichens (Thomas and Kroeger 1981; Thomas et al. 1984); however, no increase in digestibility of browse was observed. Milchunas and Baker (1982) found no relationship for between trial differences in forage digestibility and nitrogen concentration of inoculum. We digested the lichen combination for 60 hr in cow inoculum (in vivo DMD = 36.3%) but observed no increase in digestibility above the regular 48 hr fermentation (in vivo DMD = 36.1%) [Table 1].

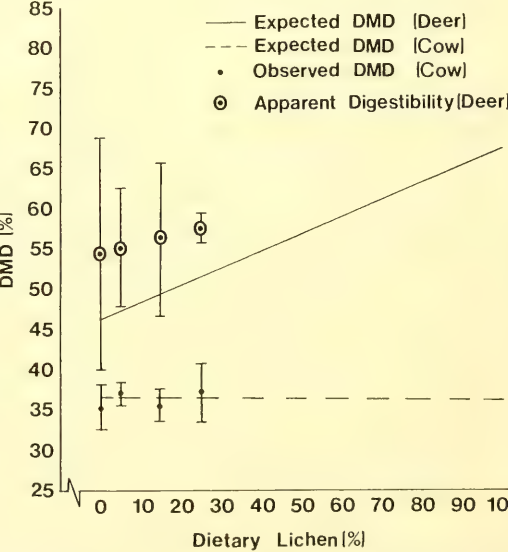


FIGURE 1. Relationship between percent lichen for four diets (0, 5, 15, and 25% lichen) containing equal portion of four conifer species and in vivo dry matter digestibility (DMD) (converted from in vitro digestions with cow and deer inocula) and apparent digestibilities determined from captive White-Tailed Deer (Jenks 1986). Bars indicate confidence intervals.

Overall digestibility for winter forages was low when digested with cow inoculum; digestibility of all forages increased when digested with deer inoculum (Table 1). Similarly, Blankenship et al. (1982) found an overall increase in digestibilities for forages fermented with deer inoculum compared to those from cow, goat, and sheep inocula. Campa et al. (1984) also found differences between forage digestibilities determined with cow and wild deer inocula, as well as a difference in forage digestibility when captive, fistulated deer were maintained on the diet being digested. Our study suggested that two inocula can produce disparate estimates of digestibility. Conversely, other researchers have found little variation in digestibility due to inoculum donor (Welch et al. 1983; Crawford and Hankinson 1984).

Differences in *in vivo* DMD of diets between inoculum sources approached 20% (Figure 1). Robbins et al. (1975) noted an 4.4% difference in digestibilities obtained using cow and deer inocula; cow inoculum overestimated browse digestibilities. Digestibilities of conifers obtained using wild deer inoculum (Rochelle 1980) were higher than those from cow inoculum (Leslie 1982). These disparities suggest that inoculum source and/or donor diet may significantly affect *in vitro* results.

Differences between expected *in vivo* DMD estimates (deer inoculum) and apparent digestibility values indicated that dietary digestibilities from summations of single species digestions can give inaccurate results. These differences may be greatest when diets contain forages of varying solubility (Milchunas and Baker 1982). In such instances, *in vitro* techniques may provide relative relationships among forages but not accurate *in vivo* digestibilities (Campa et al. 1984).

No lichen induced synergisms were found that enhanced digestibility of winter diets (digested with cow inoculum) as noted by Rochelle (1980); however, lichen diets could not be digested with deer inoculum. Calculated dietary digestibilities determined from single species summations (deer inoculum) increased as the more digestible lichen increased; *in vivo* DMD increased to levels above 50% with a minimum of 20% dietary lichen (Figure 1). Ammann et al. (1973) observed a positive energy balance in deer when diets were above 50% digestible dry matter. Available lichen may enhance energy balance during winter when poorly digested browse species make up the bulk of winter diets. Lichens also may act as carbohydrate sources to increase efficiency of urea cycling (Orskov 1982: 28).

Although lichen induced synergisms could not be demonstrated in our study, availability of lichen in winter could have important implications for deer management in boreal habitats. When lichen is not available and deer consume browse of low digestibility (< 50%), digestible energy may be limiting. Ingestion of some lichen species may increase fermentative efficiency and overall digestibility of the diet. In areas where lichens are available, dietary digestibility would be increased through an additive effect of increased dietary lichen (Figure 1).

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Age Structure Analysis of a Virgin White Pine, *Pinus strobus*, Population

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Age structure characteristics were examined in an undisturbed, mature White Pine (*Pinus strobus*) stand located at Sandford Lake in northwestern Ontario. Sample trees were aged and measured for diameter. The White Pine population showed a multi-aged distribution, a low expectation of life in the lower age classes, a higher one in later years, and a high age/diameter correlation. Fire evidence suggests that a major fire approximately 200 years ago may have stimulated initial establishment, with a more moderate fire 80 years ago contributing to a slight population increase. The multi-aged distribution points to continual recruitment as the major component of population dynamics, with the role of fire as a minor component. It is suggested that these characteristics, including mass and continual recruitment, are consistent with other White Pine populations.

Key Words: White Pine, *Pinus strobus*, time-specific analysis, life table analysis, age structure, Ontario.

The virgin forests of White Pine, *Pinus strobus*, have captured the attention of Canadians historically, first for their economic value and more recently for their significance as a natural heritage. In the past, White Pine forests grew on the vast sandy plains of southern Ontario and the lower portions of the Canadian Shield. "Over the years, Ontario's pine forests have provided the jobs, products, recreational opportunities, wildlife habitats, clean water and fresh air needed to build the province and the nation" (Aird 1985: 1). As a result, the original distribution of White Pine has been drastically altered (Stiell 1978).

Today it is difficult to imagine what "the original pine forests were like to visualize, their seemingly infinite reach and the size of the trees they contained" (Morse 1984: 10). Only a few studies have been done on undisturbed White Pine populations (Hett and Loucks 1968; Ohmann and Ream 1971). A descriptive and quantitative study of populations would contribute to the understanding of this species in general. This is particularly urgent in Ontario since there are only a few natural virgin stands left to study (Aird 1985).

Age structure analyses help to define population dynamics (Harper 1977) by summarizing important characteristics of a population, such as births, deaths, and proportion of members in each age class. Such a summary often takes the form of a life table (Silvertown 1982), which deals with probabilities of the rates of death, age-specific mortality, survivorship, and life expectancy at various time intervals over the organism's life span (Kormondy

1976). Various naturally occurring tree species have been examined using life table analyses (Davis 1966; Auclair and Cottam 1971; Yarranton and Yarranton 1975; Knowles and Grant 1983), including one study (Hett and Loucks 1968) of White Pine seedlings. In his review of plant population biology, Harper (1977) noted that there is a need for more concentrated work in life table analyses of plants.

The objective of this study is to describe the age structure characteristics using life table analyses of an undisturbed, mature White Pine population near the northern limit of this species' range.

Study Area

The study site is located on the southern shore of Sandford Lake (49°05' N and 91°41' W), midway between Atikokan and Ignace, Ontario (Figure 1). The stand occupies 34.5 hectares with 80 percent White Pine and an average stand age of approximately 140 years.

Other tree species in the overstory include Red Pine (*Pinus resinosa*), Black Spruce (*Picea mariana*), Paper Birch (*Betula papyrifera*), and Balsam Fir (*Abies balsamea*). Minor components of Trembling Aspen (*Populus tremuloides*) and Eastern White Cedar (*Thuja occidentalis*) are also present. The ages of these species are estimated at 80 years or younger, with the exception of Red Pine, which is approximately 140 years old. Most of these species are present as saplings in the understory.

Additional species present in the shrub and sapling stratum include Beaked Hazel (*Corylus*

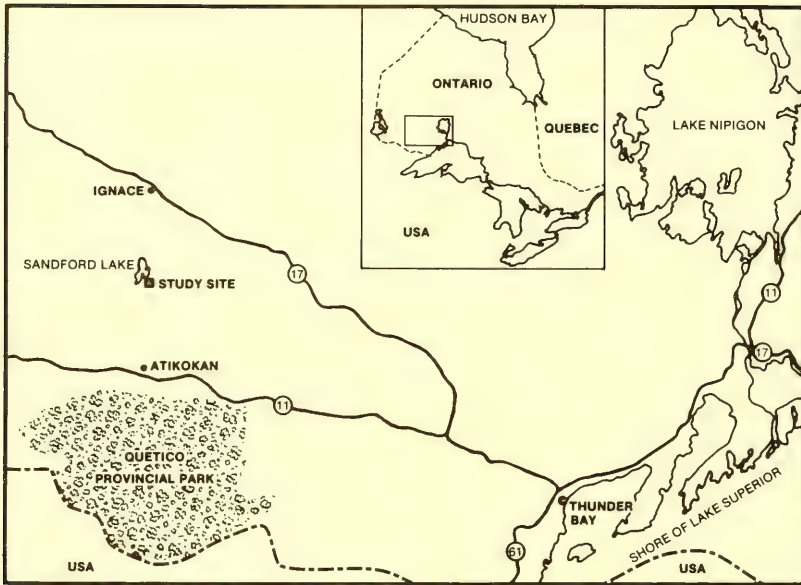


FIGURE 1. Location of study site.

cornuta), alder (*Alnus* spp.), juneberries (*Amelanchier* spp.) and Mountain Maple (*Acer spicatum*). A total of 49 woody and herbaceous species is represented in the herb and seedling stratum, with the most common being White Pine, Wild Lily-of-the-Valley (*Maianthemum canadense*), Bunchberry Dogwood (*Cornus canadensis*), Bluebead Lily (*Clintonia borealis*), Bush Honeysuckle (*Diervilla lonicera*) and Mountain Maple. The density of the understory vegetation varies from sparse to dense, depending on localized light, micro-environmental conditions, and overstory vegetation.

The terrain is composed of thin till deposits over bedrock, along with hummocky till deposits of sand and boulders, and some silt and gravel. The entire region is of glaciofluvial origin with dominant landforms of moraines and outwash plains. The local relief is characterized by ridges and plains with generally dry surface conditions.

Methods

Sampling was carried out using a systematic sampling technique called the point-centered quarter method (Mueller-Dombois and Ellenberg 1974). Parallel transect lines were run 20 m apart across the study site at a fixed point bearing. Point-centers were then marked at 30-m intervals along the transect. The tree closest to the point-center in

each of the four compass quarters measured from that point was included in the sample.

All sampled trees that were White Pine were measured for diameter, and increment cores were taken for aging. Ages for seedlings and saplings (of < 1 m in height and 4 cm in diameter) were estimated by counting bud scale scars or branch whorls. A sample of small trees was cut to verify the estimates with actual ring counts.

This point-centered quarter method was adopted to systematically sample White Pine trees for this project as well as to obtain an accurate representation of the species composition on the site for another study. It was noted, however, that the White Pine was insufficiently represented to provide adequate sample sizes in all age classes for life table analyses. Therefore, an additional sampling strategy, the transect method, was incorporated to increase the sampling intensity in a systematic manner.

For the transect sampling method, the single closest White Pine individual occurring along the transect line between the point-centers was included as a sample tree. Ageing and diameter measurements for these trees were the same as for the previous point-centre method.

Ages were estimated in the laboratory as the number of rings on the cores that had been dried, sliced longitudinally with a scalpel to expose a

clean surface, and placed under a magnifying glass for magnification.

Cores from 47 White Pine trees could not be accurately aged due to excessive rot. A number of least square regression curves, based on transformations of core age against diameter (as determined in the field) were tested in order to estimate ages. The equation with the highest coefficient of determination (r^2) was chosen to predict the ages.

Data were grouped into 10 year-age and 4 cm-diameter classes in order to construct a static or time-specific life table for examining the mortality schedule (Krebs 1978). The following characteristics were used in the life table:

- x = age interval in years
- n_x = number of survivors at start of age interval x
- l_x = proportion of individuals surviving to start of age interval x
- d_x = number dying during age interval x to $x + 1$
- q_x = mortality rate during the age interval x to $x + 1$, and
- e_x = mean expectation of further life for individuals alive at start of age x .

Results

Of the least squares regression curves fitted to the data set the best predictor of age was:

natural logarithm (age) = $2.07 + 0.705$ natural logarithm (diameter) with an r^2 value of 0.923 and a confidence level of $p < 0.001$.

The average age and range of ages for White Pine was 52.4 years and 1 to 188 years, respectively. The average diameter was 19.9 cm with a range of 0.1 to 89.5 cm.

Age and diameter distributions for White Pine (Figure 2) are expressed as percentages to simplify presentation. The time-specific life table is presented in Table 1 and is based on both the actual counts of intact cores and predicted ages from damaged cores. Each of the columns of the life table can be calculated from any other column. Thus, each column of Table 1 represents a different way of presenting the basic survivorship data.

Discussion

The relationship between age and diameter in White Pine indicates that a substantial proportion of variation in diameter is explained by age ($r^2 = 0.923$). The similarity between age and diameter is also reflected in the similar shapes of the two distributions in Figure 2 which characterize this White Pine population as a multi-aged and multi-sized population. With the exception of the substantial proportion of trees in the youngest age and size classes, these distributions tend towards stability, with similar numbers in each class. Such a distribution is characteristic of shade-tolerant

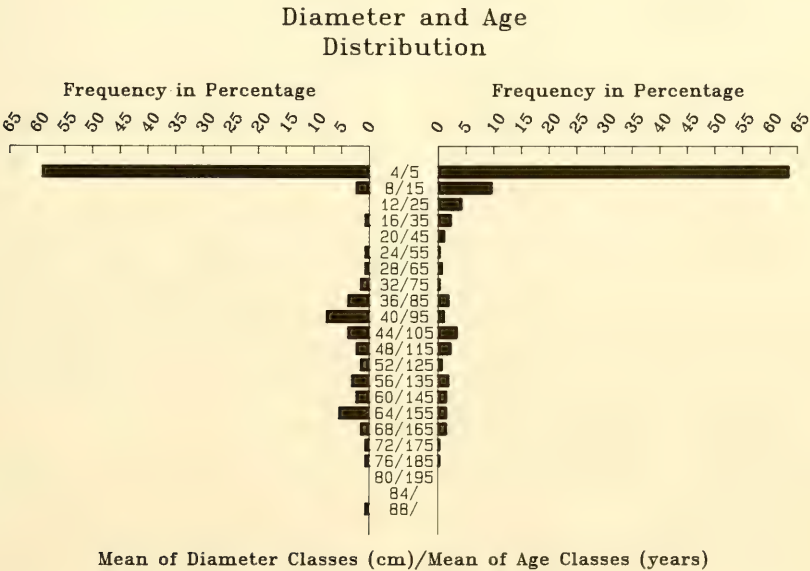


FIGURE 2. Age and diameter distributions of White Pine population.

TABLE 1. Time-specific life table for members of the White Pine population.

Age Interval (Year)	Number of survivors at start of age interval x	Proportion of individuals surviving to start of age interval x	Number dying during the age interval x to x + 1	Rate of mortality during the age interval x to x + 1	Mean expectation of further life for individuals alive at start of age x
x	n _x	l _x	d _x	q _x	e _x
0	255	1.000	162	0.635	29.610
10	93	0.365	25	0.269	62.470
20	68	0.267	11	0.162	73.600
30	57	0.224	6	0.105	76.840
40	51	0.200	3	0.059	75.290
50	48	0.188	1	0.021	69.690
60	47	0.184	2	0.043	61.060
70	45	0.176	1	0.022	53.560
80	44	0.173	5	0.114	44.660
90	39	0.153	3	0.077	39.740
100	36	0.141	9	0.250	32.640
110	27	0.106	6	0.222	31.850
120	21	0.082	2	0.095	29.520
130	19	0.075	5	0.263	22.110
140	14	0.055	4	0.286	18.210
150	10	0.039	4	0.400	13.500
160	6	0.024	4	0.667	9.170
170	2	0.008	1	0.500	7.500
180	1	0.004	1	1.000	10.000
190	0	0.000	0	—	—

climax species (Kimmins 1987). A similar, relatively stable age distribution was found in *Picea rubens* in a spruce-fir forest of the Maine coast and was characterized as representative of a “virgin” or climax forest (Davis 1966).

The large proportion of young trees in this study may seem anomalous, since age and size distributions of natural populations of other species tend towards bimodal or normal distributions (for example, see Knowles and Grant (1983)). However, very few other studies have sampled all size and age classes including trees too small to core. Our sampling design, including all classes, enables a more complete analysis of the population as a whole.

From the life table, it can be seen that the White Pine population is relatively long-lived, with representatives over 180 years. For comparison purposes, Fowells (1965) notes that “White Pine is a long-lived tree.... [and may] reach 200 years if undisturbed”. Older populations have been recorded, notably by Heinselman (1973), who studied White Pine communities in northern Minnesota, where the oldest attained ages ranging from 323 to 368 years.

The mortality column of the life table (q_x) further indicates that seedlings suffer substantial

mortality in the initial ten-year class, with a notable decrease in mortality thereafter. The statistical implication of this massive seedling mortality is an overall low expected longevity. For example, the longevity column (e_x) indicates that expected longevity of the youngest age class is only 29.61 years but rises to 76.84 in the 30–40 year age class. Thus, White Pine seedlings have high mortality, but plants that survive through this period have a high probability of longevity.

The broad age distribution of White Pine indicates that this population is dynamic, with continual recruitment. Even though it is located close to the margin of White Pine’s geographic distribution, the population has maintained itself and will likely continue to do so. Information on geographically marginal populations of White Pine is limited, as is any information on virgin White Pine stands. Thus, establishment and maintenance of these marginal populations are yet poorly understood.

Davis (1983) suggests that 5000 years ago White Pine had migrated north of its present range limit in Canada. This population could thus be the remnant of a previously large, now diminishing, natural distribution (Devey and Flint 1957; Fowler

1964). It has also been suggested that many of the present White Pine stands in Canada are relic stands maintaining themselves solely because of local soil or fire disturbance conditions (Horton and Bedell 1960).

The results of this study are consistent with the ecological characteristics associated with White Pine's association with fire disturbance (Heinselman 1973). Initial survivorship strategy is one of mass recruitment following chance disturbance, especially fire. Mature White Pine trees have unusually thick bark, making them fairly resistant to fire (Fowells 1965). Crown scorch is this species' usual limitation on survival (Van Wagner 1970), although cambial damage also occurs.

It can be hypothesized that, following a large fire that burned the forest approximately 200 years ago, the present older age class was initiated. After an initial period of establishment and crown closure, White Pine may have exhibited continual recruitment, creating a multi-aged stand as new individuals became established in the understory. Evidence of fire-scarred stumps were present on the site. These stumps may be remnants of the parent population responsible for the initial establishment or of a second fire of low-to-moderate intensity that burned through the area approximately 80 years ago.

Fire scars noted on some mature White Pine stems and the absence of understory trees of other species over 80 years of age provide evidence for a more recent, moderate fire. Further evidence is provided by the age distribution (Figure 2), which indicates a slight increase in the number of White Pine trees in the 80–90 year class relative to the adjacent age classes, both older and younger. We emphasize that the multi-aged distribution points to continual recruitment as the major component of population dynamics, with the role of fire as a factor contributing either to initial establishment or minor, sporadic population fluctuation.

In summary, these results suggest a scenario of continual recruitment, with a multi-sized diameter distribution, high age/diameter correlation, high mortality of young trees, and evidence of fire disturbance. We expect that these characteristics would be representative of White Pine stands on favourable sites throughout its geographic distribution.

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Ecology of the Mule Deer, *Odocoileus hemionus*, Along the East Front of the Rocky Mountains, Montana

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Mule Deer, *Odocoileus hemionus*, wintering along the east slope of the Rocky Mountains from Sun River to Birch Creek in north-central Montana were found to represent seven herd units. Distribution and movement patterns of deer in each herd unit were influenced by the topography and vegetation on winter ranges and in the mountains west of winter ranges. Each herd unit consisted of deer that were yearlong residents on or near winter ranges, deer that summered in valleys near the winter range, and deer that moved 20 or more km to mountain summer ranges. Movement patterns and apparent vulnerability to hunting varied among segments. Degradation of mountain front winter ranges through intensive oil and gas development could significantly reduce Mule Deer numbers in large areas of the Rocky Mountains.

Key Words: Mule Deer, *Odocoileus hemionus*, population ecology, Montana.

Mule Deer, *Odocoileus hemionus*, populations along the East Front of the Rocky Mountains represent a valuable resource that could be detrimentally affected by hydrocarbon exploration and development in the overthrust formations that underlie the mountain front in the United States and Canada. Management of Mule Deer in the face of oil and gas development requires knowledge of the distribution, seasonal movements, and other ecological attributes of populations dependent on the mountain-prairie ecotone along the East Front. This information is broadly lacking for Mule Deer in the northern Rocky Mountains, where intensive studies involving marked and radio-collared animals and close population monitoring have been conducted in only a few areas.

Our study, conducted primarily between 1979 and 1983, provides some of the needed information for Mule Deer populations along a 64-km segment of the Rocky Mountain Front in north-central Montana. The results should be relevant to management of Mule Deer populations along the front range from central Montana northward into Canada.

Study Area

The 2725-km² study area was located in, and adjacent to, the Sawtooth Range in north-central Montana (48° N, 113° W). Southerly and northerly extensions of this range follow the Continental Divide from about Helena, Montana, to Jasper, Alberta.

Terrain on the Sawtooth Range is characterized by a series of parallel north-south faults with moderate west-facing slopes and precipitous east faces. Elevations range from 1311 to 2863 m. A narrow (1 to 3 km) band of foothills marks the transition between plains and mountains and provides most of the wintering areas for native ungulates. Major vegetation types in the study area included fescue — wheatgrass (*Festuca* spp. — *Agropyron spicatum*) grasslands, Limber Pine (*Pinus flexilis*) savannah, and forest dominated by Douglas-fir (*Pseudotsuga menziesii*), Alpine Fir (*Abies lasiocarpa*), or Lodgepole Pine (*Pinus contorta*). Annual precipitation recorded at weather stations near the study area averages 35 to 56 cm. Average annual temperature is about 5° C (U.S. Department of Commerce 1985). Winter snow cover is variable along the mountain front and is influenced by strong southwesterly chinook winds.

Over 90% of the total study area was administered by the United States Forest Service (USFS), U.S. Bureau of Land Management (BLM), and the Montana Department of Fish, Wildlife and Parks (MDFWP). However, more than 80% of the surface and 44% of the subsurface mineral (oil and gas) rights on Mule Deer wintering areas were privately owned or administered.

Methods

Mule Deer were divided into three groups according to range: the East of Divide, EOD,

population segment; the West of Divide, WOD, population segment; and the Resident, RES, segment.

Mule Deer were captured using baited panel traps (Lightfoot and Maw 1963) and a helicopter drive-net (Beasom et al. 1980) on wintering areas during 1976 through 1982. Twenty-six were radio-collared and 124 were marked with individually recognizable neckbands. Radio-collared deer were relocated from fixed-wing aircraft one to three times per month from March 1979 through October 1981 and approximately once every other month from November 1981 to December 1982. Relocations during the first period were used to calculate seasonal home ranges using a minimum convex polygon approach (Lonner and Burkhalter 1986). Additional relocations of radio-collared and marked deer, used in the delineation of seasonal distributions and movements, were obtained by aerial and ground observations in the course of population surveys and other activities, and occasionally from returns of marked animals shot by hunters.

Winter distribution, movements, and habitat use were further defined, and population characteristics determined, through ground and aerial surveys. The latter included nine helicopter surveys, two each in mid- and/or late winter 1979 through 1982 and one in January 1983, which provided complete or near-complete coverage of wintering areas. Ground classifications (age/sex ratios) during 1960 through 1978 and helicopter surveys in 1975 and 1978 by MDFWP management personnel provided supplementary data.

Population size estimates for 1980 through 1982 were derived as Lincoln Indices (Overton and Davis 1969) based on observations of marked and unmarked deer during complete-coverage helicopter surveys of winter ranges in March (Mackie et al. 1981). Population estimates could not be made for 1979, when few marked animals were available, and for 1983, when the helicopter survey was flown in mid-January and did not include one major winter range. Trapping operations during 1976 through 1981 provided known marked samples of 92, 107, and 50 at the time of March surveys in 1980, 1981, and 1982, respectively.

Ages of animals captured during helicopter drive-netting were estimated on the basis of tooth replacement and wear by Dave Pac, MDFWP. In known-age deer, 2½ to 6½ years old from the Bridger Mountains of southwestern Montana, approximately 90% of age estimates obtained using tooth wear were within 1 year of actual ages (D. Pac, personal communication). Harvest data

were obtained from the MDFWP (Federal Aid Job Progress Reports, unpublished).

Results

Seasonal Distribution and Movements

Seven Mule Deer winter ranges were identified in the study area (Figure 1). These varied in size during the 1980 and 1981 winters from 10 km² to 24 km² for primary range and from 26 km² to 81 km² for total winter range. One, Swanson Ridges, apparently had been little used by deer during the mid 1970s but received consistent use during 1979 through 1983 as populations increased along the Front.

Primary winter range (Figure 2) supported deer concentrations in all winters, although the extent and period of concentration on primary winter range varied with winter severity. For example, in 1979, one of the harshest winters of this century (U.S. Department of Commerce 1979–80), deer on the Blackleaf-Teton winter range moved 3 km south of their concentration areas in other winters.

Total winter range included secondary ranges used in early and late winter or under abnormal conditions. Use of secondary winter range varied extensively between years and was apparently linked to snow cover.

Marked deer showed a high degree of fidelity to specific winter ranges as well as to individual home ranges within winter ranges. All radio-collared deer returned annually to the winter ranges on which they were trapped. Only one, an adult doe, significantly changed her activity center within a winter range between years. Among neck-banded deer, only four males (three yearlings and a 3½ year old) were known to have changed winter ranges. Annual winter range size for individuals varied from 0.4 to 13.0 km² for 19 females and from 0.7 to 6.0 km² for two males. Female winter home ranges averaged 3.4, 4.6, and 6.0 km² in 1979 (March to mid-May only), 1980, and 1981, respectively (Table 1). Cumulative winter ranges for 10 females followed through three winters averaged 15.9 km².

Secondary winter range overlapped or included some transitional range (areas on which deer concentrated during spring and/or fall). Transition ranges were generally adjacent to winter range but at higher elevations (Figure 2). Radio-collared deer with summer ranges west of the Continental Divide (the WOD population segment) tended to use transitional range for two to three months in autumn before moving on to winter range. Movements of this segment to transition range coincided with late October or early November

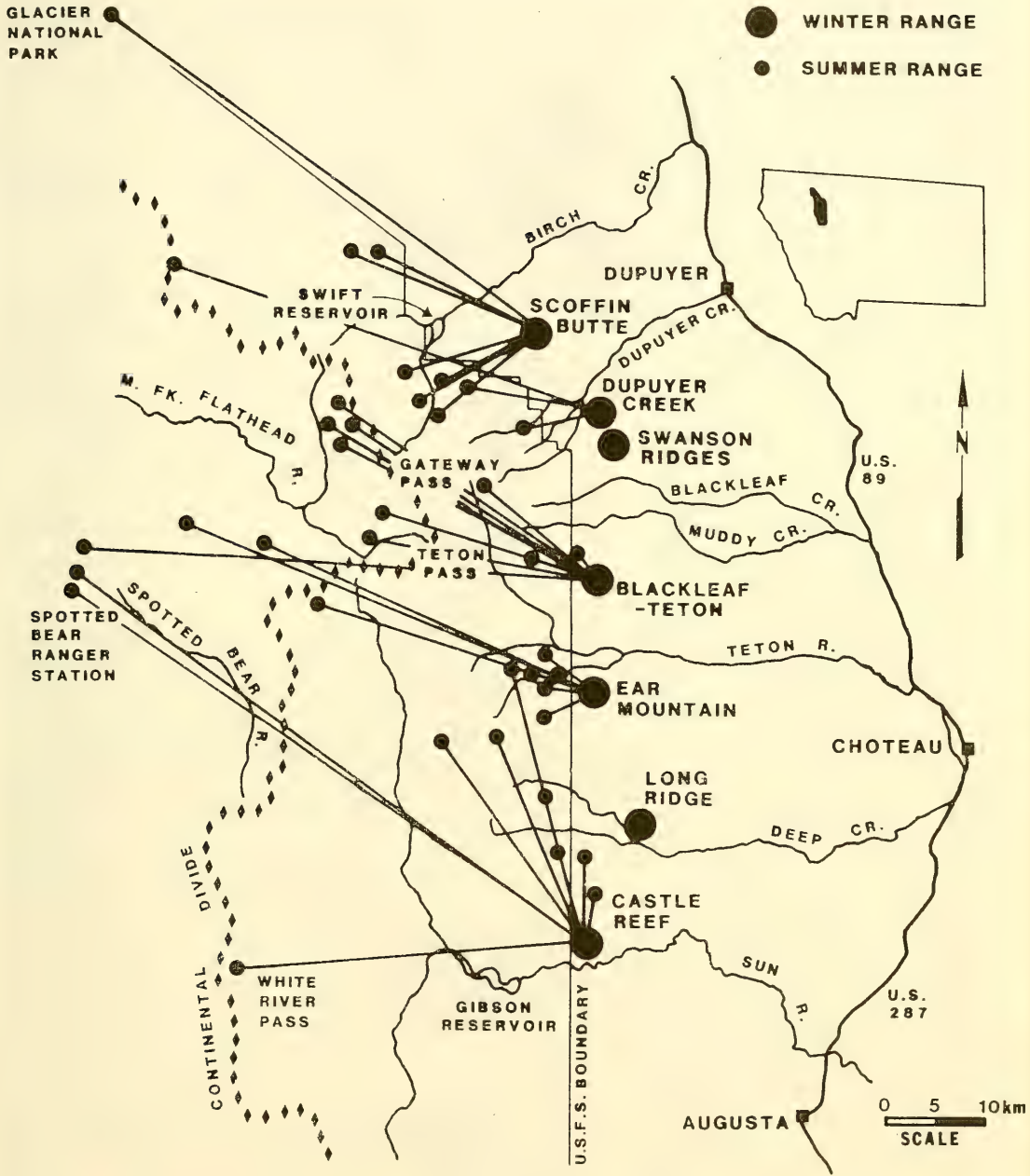


FIGURE 1. The East Front study area showing locations of winter and associated summer ranges used by marked Mule Deer.

snowstorms during the period 1979 through 1981. Deer summering in mountain valleys east of the Divide (the EOD population segment) and along

the lower mountain front (the RES segment) either moved directly to winter range between late November and late December or moved on to

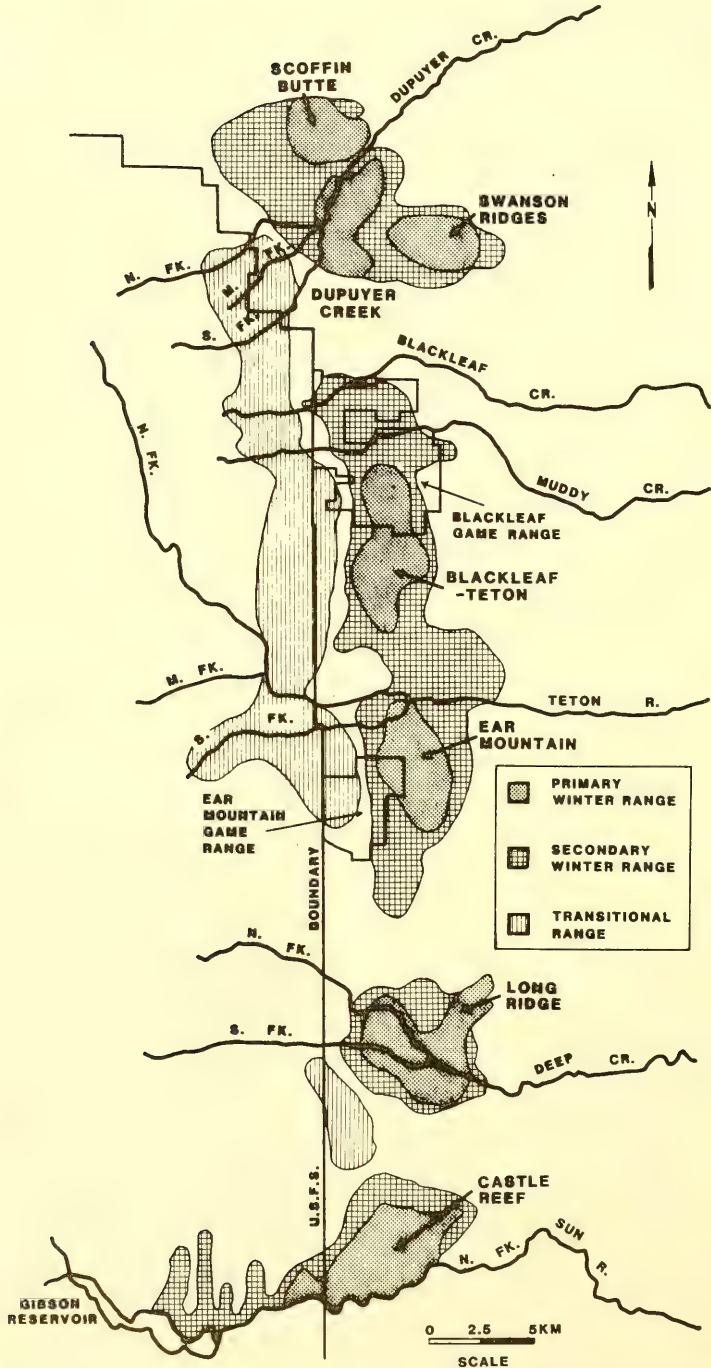


FIGURE 2. Primary, secondary, and identified transitional ranges used by Mule Deer wintering in the East Front study area.

TABLE 1. Seasonal home range sizes (km²) for radio-collared Mule Deer along the East Front, Montana. Only animals followed through three summers (June to October/November) or three winters (December to May) are included in cumulative ranges.

Season	Female			Male		
	N Animals	Mean N relocations	Range size (SE)	N Animals	Mean N relocations	Range size (SE)
Winter 1979	12	6	3.4 (0.8)			
1980	18	7	4.6 (0.7)	1	6	3.6
1981	16	8	6.0 (1.0)	2	6	3.4 (2.6)
Cumulative Winter	10	22	15.9 (3.3)			
Summer 1979	14	12	6.4 (1.1)			
1980	17	8	3.5 (0.7)	2	6	4.5 (0.8)
1981	11	7	1.4 (0.5)	2	6	18.3 (9.1)
Cumulative summer	7	27	11.1 (2.5)			

transition range up to eight weeks later than WOD deer. WOD and EOD deer returned to transition range in late May or early June enroute to summer range.

Radio-relocations and sightings of neck-banded individuals (Figure 1) allowed us tentatively to define annual distributions for deer associated with five winter ranges. These data indicated that deer associated with individual winter ranges constituted population units occupying relatively discrete year-long herd ranges. The size (Table 2) and shape of these ranges apparently reflected traditional patterns of movement and range usage by individual deer or groups of deer associated with each winter range as well as habitat characteristics (e.g. topography, vegetation, climate) of terrain west of the winter ranges.

Most of the population units included segments or sub-populations composed of long-distance migrants (generally WOD deer), relatively short-distance migrants (generally EOD deer), and animals resident on the winter range and immediately adjacent areas (RES deer). The proportion of deer in each segment varied among units, apparently in relation to the amount of suitable habitat, ease of access, and distance to areas west of the Continental Divide, and possibly as a function of traditional movement patterns.

A relatively high proportion of deer in the Blackleaf-Teton unit summered west of the divide in the upper reaches of the Middle Fork of the Flathead River drainage. Limited amounts of suitable summer range were available within the EOD and RES segments of this herd range. EOD summer ranges, especially those of adult females, were primarily restricted to the bottoms and lower timbered slopes of Blackleaf Canyon and a series of short, narrow side canyons that extend north and south of the Teton River.

In contrast, the Castle Reef, Ear Mountain, Dupuyer Creek, and Scoffin Butte winter ranges were relatively distant from the divide, and larger areas of suitable summer range occurred within the broader, longer drainages that characterized the EOD and RES segments of their respective herd ranges. Between two-thirds and three-quarters of the known summer ranges of deer marked on these ranges were within 20 km, airline, of winter range compared with about one-third of the deer marked on the Blackleaf-Teton.

Calculated summer home range size in individual years varied from 0.2 to 13.5 km² for 19 females and from 2.6 to 34.0 km² for three males. Mean summer home range size for females was 6.4, 3.5, and 1.4 km² in 1979, 1980, and 1981, respectively (Table 1). Cumulative home range size for seven females followed through three summers averaged 11.1 km².

TABLE 2. Population unit ranges (primary winter, total winter, transition range, and minimum yearly range) and mean estimated population numbers (counts divided by the proportion of marked animals seen in four helicopter surveys, March and April 1980 and March and April 1981) for Mule Deer on winter ranges along the East Front, Montana.

Location	Range (km ²)				Mean estimated population ^a (SE)
	Primary winter	Total winter	Transition	Minimum yearly	
Hunting District 441 (North of Teton River)					
Scoffin Butte	10.2	26.6		575	905 (42)
Dupuyer Creek	13.4	31.6	24.9	359	1073 (50)
Swanson Ridges	10.6	29.2			
Blackleaf-Teton	20.9	80.8	53.5	328	546 (86)
Hunting District 442 (South of Teton River)					
Ear Mountain	16.6	44.0	47.1	375	594 (105)
Long Ridge	23.9	37.6			1104 (245) ^b
Castle Reef	18.1	38.9	12.3	1056	1224 (211)

^aMeans are based on counts in March 1980, April 1980, March 1981, and April 1981 divided by 0.62, 0.65, 0.56, and 0.48, respectively.

^bMean based on three counts (January 1980, January 1981, and March 1981).

Population Characteristics and Trends

Population Size and Density — Counts in seven helicopter surveys which approached complete coverage of all winter ranges ranged from 2282 (April 1979) to 5093 (January 1982). Our best estimates of minimum total Mule Deer numbers on winter range were 5653 in March 1980, 6016 in March 1981, and 5956 in March 1982. During those surveys, we sighted 62%, 56%, and 56% of the known marked deer available. Sightability ranged from 48% to 65% for four other helicopter surveys (two in January and two in April) during 1980–1983.

If deer sightability in our study area during the severe 1979 winter was intermediate to sightability during the same winter in the Bridger Mountains of southwestern Montana (64%) and the Missouri Breaks of central Montana (74%) (Mackie et al. 1981), the count obtained from the February 1979 MDWFP complete coverage survey, 3532, would suggest that approximately 5000 Mule Deer wintered on the study area in late winter 1979. Only 2753 deer were counted during the 1983 survey. However, weather conditions were exceptionally mild, deer were widely distributed in January when the survey was conducted, and a portion of one winter range was not covered.

The apparent 6% population increase from March 1980 to March 1981 was consistent with other observations which indicated growth in wintering populations on the Front from 1977/

1978 through 1981. Our data suggested that the population stabilized in 1981–1982; the single, early winter 1983 count did not provide a valid estimate of trends to 1983.

Density estimates on individual winter ranges, based on mean counts from helicopter surveys in 1980–1981 adjusted for the proportion of marked animals seen in each survey, indicated an inverse relationship between deer density and both total population unit range and winter range size (Table 2). The Castle Reef Winter Range supported the highest average number of deer and Blackleaf-Teton the lowest, during 1980–81.

Population structure — Since no significant differences were noted between fawn to adult ratios obtained from ground and helicopter classification data in a sample of eight winter range by year combinations during 1981–1983 (paired *t*-test; mean ground ratio = 49, mean helicopter ratio = 46; *t* = 0.275; *p* > 0.10), the most comprehensive data sets available (ground surveys in 1980–1981 and helicopter surveys in 1982–1983) were used to examine trends in productivity. Fawn to adult ratios, based on early (January–February) and late (March–April) winter classifications, suggested that fawn production/survival was moderately high overall but may have declined from 1980 to 1982 (Table 3). The mean ratio for all winter ranges in 1980 was above the 1961–1979 mean of 52 fawns per 100 adults for winter ranges along the Front (Kasworm 1981), while those for

TABLE 3. Fawn to adult ratios (fawns/100 adults) recorded on six winter ranges between January and February and between March and April along the East Front of the Rocky Mountains, Montana. Ratios for 1980-81 were obtained from ground surveys and those from 1982-83 from helicopter surveys. Numbers of animals classified as adults or fawns are given in parentheses.

Year	Winter range					
	Scoffin Butte	Dupuyer Creek- Swanson Ridges	Blackleaf- Teton	Ear Mountain	Castle Reef	Long Ridge
1980						
January-February	69 (687)	66 (575)	76 (232)	64 (171)	70 (416)	
March-April	60 (48)	67 (275)	58 (331)	62 (202)	61 (148)	
1981						
January-February	54 (559)	35 (188)	55 (175)	57 (327)	42 (306)	
March-April	46 (291)	52 (449)	44 (286)	54 (356)	54 (159)	
1982						
January-February	28 (82)	51 (113)	58 (503)	31 (356)	36 (233)	64 (224)
March-April	38 (153)	45 (193)	56 (39)	48 (346)	47 (258)	55 (31)
1983						
January-February	53 (388)	48 (233)	39 (133)	52 (147)	58 (391)	56 (182)

1981, 1982, and early winter 1983 were similar to or only slightly below the mean. Overwinter mortality was apparently low in all years. Although ratios varied somewhat between individual winter ranges, the differences were not significant (Chi-square, $p > 0.05$).

Males constituted 16%, 17%, and 19% of 1445, 1516, and 1475 animals classified in helicopter surveys during January 1981, 1982, and 1983, respectively. Sex ratios determined from helicopter classifications in January 1982 and 1983 indicated 34 and 40 males per 100 females for all winter ranges combined. Small samples classified on some winter ranges precluded assessment of possible differences among individual ranges. Moderately high male to female ratios on the area were also indicated by sex ratios of deer handled in drive netting operations—35 males per 100 females in 1980 and 55 per 100 in 1981.

The drive-netting operations also provided data on age structure. Yearlings and fawns constituted 39% of 68 animals trapped in 1980 and 43% of 42 handled in 1981. The oldest discernable age group, 6 1/2 years and older, made up 6% and 12% of the two samples (Figure 3).

Mortality — A minimum of 70% of 84 marked adult females survived for at least one year following capture; only four (5%) were known to have died, while fates of 21 were unknown. Among fawns, a minimum of 56% of 32 marked were known to survive at least one year, none were

known to have died, and the fates of 14 were unknown. Of the 26 marked adult males, five (27%) survived, seven died, and the fates of 12 were undetermined.

Winter mortality appeared to be low in all years, as evidenced by little or no change in fawn to adult ratios from early to late winter. Deer harvests in the study area were generally light (200–300 animals/year) during 1979–1983. Regulations allowed harvest of one deer per hunter, and hunting was limited to bucks only except for a two-week, either-sex period. Mild autumn conditions during the study resulted in deer dispersing widely during the hunting season and low vulnerability of deer to hunters. None of our marked females were known to have been shot, at least in the first year following marking. Hunting was the major known cause of mortality among males, with six of the seven known deaths being hunter returns.

Discussion

Historically, all deer inhabiting the East Front and adjacent summer ranges have been considered a single population. Subunits have been arbitrarily defined to include animals occurring within hunting districts established primarily for administrative purposes. In contrast, our findings indicate Mule Deer associated with individual winter ranges along the East Front constitute discrete population units distributed within individual year-long ranges. This distributional

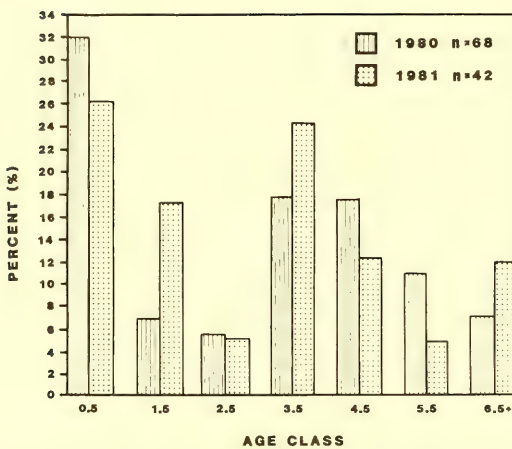


FIGURE 3. Age distribution of Mule Deer examined during trapping operations in the East Front study area during 1980 and 1981.

pattern is similar to that described for Mule Deer populations in the Bridger Mountains of southwestern Montana (Mackie and Pac 1980; Pac et al. 1984) and may represent the general pattern followed by Mule Deer on mountain-foothill habitat in the northern Rocky Mountains.

Summer and winter home range sizes were similar to those calculated for Mule Deer in the Bridger Mountains (Pac 1976; Steery 1979; Nyberg 1980; Rosgaard 1981) using similar data collection and analysis techniques. The large difference between cumulative and annual seasonal home range sizes was also noted in the Bridgers and may be either a function of small annual samples or an artifact of home range calculation using the minimum polygon approach (MacDonald et al. 1980).

The size and shape of the herd units apparently reflected traditional patterns of movement and range usage by deer from each winter range as well as habitat/environmental features of the area accessible to, or traditionally used by, those deer. The fact that numbers and density of deer varied between units suggested a possible functional relationship between environmental features and demographic characteristics of Mule Deer in each unit.

Our population studies were not sufficiently intensive to detect differences in parameters such as sex and age structure, reproduction, mortality rates, etc.. Studies elsewhere in Montana (R. J. Mackie, D. F. Pac, and H. E. Jorgensen. 1978, 1980. Population ecology and habitat relation-

ships of Mule Deer in the Bridger Mountains, Montana. In Montana Deer Studies Job Progress Report, MDFWP, Helena) have shown that deer-habitat interactions and population characteristics vary between individual population units: the broader the difference in habitat, the greater the difference in population parameters and dynamics. Similarly, Barlow and McCulloch (1984) suggested that the Kaibab Mule Deer herd, which has long been considered a single population, may comprise two sub-populations experiencing different environments and exhibiting different biological characteristics.

White-tailed Deer, *Odocoileus virginianus*, associated with individual winter yarding areas in the same winter range in Minnesota have been found to be separate sub-populations (Nelson and Mech, *in press*). Other studies of White-tailed Deer (Dapson et al. 1979; Ramsey et al. 1979) have defined differences in demographic characteristics between populations in different adjacent habitats which were associated with differences in genetic homogeneity between populations.

In the past, under existing administrative boundaries, deer inhabiting ranges east and west of the Continental Divide have constituted separate subunits, and East Front winter ranges were considered to support primarily EOD deer. Our findings indicate that most Mule Deer occupying the portions of the Bob Marshall Wilderness Area and the Flathead and Lewis and Clark national forests lying north of the Sun River, south of Glacier National Park, and east of the upper South Fork of the Flathead River must winter along the East Front within our study area. Deer management surveys (J. Cross, J. McCarthy, and G. Olson, personal communication) have indicated that very few Mule Deer winter west of the Continental Divide within that area. This would imply that maintenance of summering Mule Deer populations within that 3000 km² area is directly dependent upon the amount and quality of winter range available along the East Front. Conversely, maintenance of maximum Mule Deer populations on East Front winter ranges depends upon habitat and population management practices within that entire area of summer range.

The movement of WOD deer to transitional and winter ranges on the East Front with snowstorms in late October or early November, and movement of EOD deer later in November or in December, are consistent with findings from other studies (Pac 1976; Steery 1979; Nyberg 1980; Rosgaard 1981) involving Mule Deer populations with herd ranges split by a major mountain divide. This

differential movement may be of special significance in harvest management along the East Front. Hunter access is typically highest in the vicinity of winter ranges. The earlier movement of WOD deer likely results in greater hunting pressure being applied on them compared to EOD deer, which remain more widely dispersed and at somewhat higher elevations during late October and November. Such differential harvest, if excessive, could lead to gradual reduction and eventual elimination of the WOD segment or prevent Mule Deer from completely "filling" (Mackie 1983) available summer habitat west of the Continental Divide.

During 1980–1985, population densities and structure on winter ranges in the study area fell within the range of values reported for healthy, productive Mule Deer populations in other mountain-foothills habitats in Montana (R. J. Mackie, D. F. Pac, and H. E. Jorgensen. 1978, 1980. Population ecology and habitat relationships of Mule Deer in the Bridger Mountains, Montana. *In* Montana Deer Studies Job Progress Report, MDFWP, Helena). The intermittent and widely scattered hydrocarbon development in the study area had no detectable impact on Mule Deer distribution, numbers, or productivity (Ihsle 1982; G. Olson and J. McCarthy, personal communication).

Should intensive, unplanned and unregulated development occur on winter concentration areas or should hunter pressure increase markedly as a result of increased road density or greater human populations, the recreational and esthetic benefits provided by Mule Deer in vast areas of the northern Rocky Mountains could be jeopardized. To avoid this possibility, herd units, seasonally important use areas, and characteristic herd structure for healthy populations should be identified along the entire Rocky Mountain Front prior to widespread development of oil and gas fields. Management plans could then be tailored to individual herd units rather than broad geographic areas, and general regulations could be replaced with specific management goals that would be more beneficial to Mule Deer populations and would include fewer unnecessary impediments to oil and gas development.

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Aspects of History and Nestling Mortality at a Great Blue Heron, *Ardea herodias*, Colony, Quetico Provincial Park, Ontario

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Sullivan, Joseph P., and Susan M. Payne. 1988. Aspects of history and nestling mortality at a Great Blue Heron, *Ardea herodias*, colony, Quetico Provincial Park, Ontario. *Canadian Field-Naturalist* 102(2): 237–241.

Baseline population data were collected from 1964–1982 at a Great Blue Heron, *Ardea herodias*, colony in a region susceptible to lake acidification. More complete nesting ecology data were gathered during the 1982 nestling season. From 69 active nests, an estimated 2.2 young fledged per nest. Primary causes of mortality were sibling rivalry and premature first flights. Sibling aggression was greater than at other localities reported in the literature, perhaps due to the size of fish being fed to the young. The population appeared to be healthy and increasing.

Key Words: Great Blue Herons, *Ardea herodias*, nestling mortality, sibling rivalry, Ontario.

Great Blue Herons, *Ardea herodias*, are mainly piscivores, and should be affected by acid precipitation or other disturbances that lead to reduced fish populations. The Boundary Waters Canoe Area of Voyageur's National Park (BWCA) in Northern Minnesota and adjacent Quetico Provincial Park (QPP) in western Ontario are areas susceptible to lake acidification (Glass et al. 1979). Since Great Blue Herons may forage up to 20 miles from a large nesting colony (W. Brooks, personal communication), many smaller susceptible lakes may fall within their range and detrimental effects on the population may appear before relatively large lakes show significant acidification.

This study provides important baseline data for future analysis of effects of acid precipitation. Although the Great Blue Heron is North America's largest and most widely distributed ardeid (Palmer 1962), data on it are lacking from this region of the continent. Dunn et al. (1985) reported on the status of many nesting colonies throughout Ontario, but did not include their history or other detailed information on them. The historical compilation and study of nesting ecology in 1982 reported here demonstrate fluctuations in colony numbers through the years and allow discussion of the causes of nestling mortality.

Study Site

Nestling mortality and provisioning rates to nestlings were determined by us at a heronry on "Rookery Island" (48° 4'N, 91° 32'W) in Merriam Bay of Basswood Lake in QPP. Observations were

made from 16 June through 31 July 1982. Park regulations precluded earlier observations or the construction of blinds.

Rookery Island was covered by a mature forest of mixed Red Pine, *Pinus resinosa*, and White Pine, *P. strobus*. Nesting herons have killed most of the nest trees. Previous studies by the Associated Colleges of the Midwest (ACM) Wilderness Field Station found slightly lower pH values for soil samples within the colony than from surrounding soil. Whether this small increase in acidity would be sufficient to cause death of the pines was unclear. The opening of the canopy has allowed Northern White-cedar, *Thuja occidentalis*, Balsam Fir, *Abies balsamea*, White Birch, *Betula papyrifera*, and Common Choke Cherry, *Prunus virginianus*, to invade. Approximately 70% of the heronry floor was covered by Common Elder, *Sambucus canadensis*.

We also compiled and analyzed unpublished population data collected since 1964 by many students of the ACM Wilderness Field Station for this heronry which has been in existence since at least 1920 (letter from Park Ranger, R. Holliday).

When monitoring of the colony was first undertaken in 1964, the heronry was located on a small peninsula northwest of its present location. A fire in 1961 had caused a move of approximately 200 m west (R. Holliday, letter). In 1967–1968, the herons began nesting in the present location, skipping over 100 m of a pine-covered ridge. The death and falling of the nest trees appeared to be the primary cause for the movement.

In 1982, the colony consisted of 60 active nest trees containing 69 active nests. Of the active nest trees, 78% were dead; 3 were White Pines and 57 were Red Pines. Heights of nests measured ranged from 20.6 to 36.3 ($\bar{x} \pm \text{S.D.} = 26.7 \pm 4.0$, $n = 31$). Tree diameters were 0.31 to 0.69 m ($\bar{x} \pm \text{S.D.} = 0.48 \pm 0.08$, $n = 31$).

Methods

All observations were made from the ground using 7 × 35 binoculars and a 20 × spotting scope. Two viewpoints were used, from which 47 nests could be observed, 50–100 m away. These points provided viewing angles from 10° – 40° below the nests. Observations were made during periods between 0445–2130 CDT. Four nestling population counts were made, and provisioning rates were recorded beginning when the nestlings were two to four weeks old. Mean provisioning rates were determined by dividing the total number of feedings per nest by the number of nests observed.

The lack of blinds did not appear to alter heron behavior. Adults were not observed to leave when researchers walked below nests. Nestlings near the viewpoints were often fed, indicating the herons were not prevented from feeding their young by our presence.

Results

During the nine years in which the colony was monitored (Table 1), nestling numbers ranged from a maximum of 224 in 1965 to a minimum of 57 in 1968. The mean number of active nests over the 18-year period was 60.8 nests ranging from 88 in 1965 to 31 in 1968. The decline in 1968 may have resulted from chlorinated hydrocarbon spraying for spruce budworm throughout the entire region. Bald Eagles, *Haliaeetus leucocephalus*, and Ospreys, *Pandion haliaetus*, also showed reduced numbers at this time (W. Brooks, personal communication). The colony gradually increased from after 1968 until 1982 (Table 1). Data from years other than 1982 did not provide numbers of

nestlings fledged, because observation periods were often of a week or less and were either too early to determine numbers fledging or occurred after fledging had already begun.

The first nestling population count in 1982 (Table 2) was made from 20 to 23 June while the nestlings were two to four weeks old. A total heronry estimate of 186 nestlings was calculated by multiplying 2.7 (mean nestlings per nest from nests sampled) by 69 (total number of active nests). Due to the difficulty of conducting censuses from the ground, no single count included all active nests.

An estimated 34 nestlings (18.3%) died during the study prior to 17 July (Table 2). Some nestlings may have fledged before that date as McAloney (1973) found broods fledging at 6.5 weeks after hatching, but no young were observed making successful flights before 17 July. Once the young began to fledge, an accurate nestling count could not be assured, because a missing nestling might either have died or fledged.

Sibling rivalry led to several deaths, possibly as many as fourteen. Two nestlings were observed falling from nests as a result of aggression from nestmates. Another was found on the ground with peck marks on head and back. Ten other nestlings were observed lying in the nest or hanging from the nest or a branch just below. Upon the arrival of an adult for a feeding, the nestlings often fought, forcing one to the edge of the nest. The aggressor(s) pecked at or grasped the back, back of neck, or head of the attacked young, which remained at the edge of the nest, usually until the feeding was complete. Often, the victim received no food during the feeding.

One young that died from direct aggression was forced from the nest and was harassed for 16 min before falling. Subsequent examination showed peck marks on head, neck and back. In another nest, the smallest of four nestlings was forced to the edge of the nest during all observed feedings from 8 to 19 July. On 20 July, that nestling was missing. In both cases, food monopolization probably

TABLE 1. Fluctuations in numbers of active nests and nestlings from 1964 to 1982

	1964	1965	1968	1972	1973	1974	1975	1980	1982
Active nests	87	88	31	47	51	50	67	58	69
No. of nestlings	190	224	57	92	100	98	131	114	152*
Nestlings/nest	2.2	2.5	1.8	2.0	2.0	2.0	2.0	2.0	2.2

*Number of young fledged.

TABLE 2. Number of young recorded from 1982 nesting season.

Count date	No. of nests counted	Total young counted	Mean young per nest	Total young estimated
20-23 June	56	150	2.7	186
27-29 June	65	160	2.5	172
9-10 July	68	159	2.3	159
17 July	67	148	2.2	152

weakened an already smaller nestling until it could be ejected from the nest.

Premature first flights led to at least three deaths. These young were observed to have flown from nests, but, lacking coordination to land, had entangled themselves in branches of nearby trees. One fledgling was found sitting on a low branch, unable to fly back to the nest. Two were found on the ground, one with a broken leg. The falling of a dead tree on 20 July flushed many nestlings off their nests. Because this occurred after fledging had begun, it could not be determined whether any of these birds died as a result.

By 17 July, the first nestlings had fledged; by 31 July, more than 70% had fledged. Their flights

back and forth between nest trees made the nestling count of 46 on 31 July (not included in Table 2) unreliable. Many fledglings returned in late afternoon to roost overnight. Young herons were observed standing in bays of Basswood Lake during the day, though none were observed feeding.

Provisioning rates ($\text{Feedings} \cdot \text{nest}^{-1} \cdot \text{h}^{-1}$) gradually decreased throughout the observed nestling season (Figure 1). Because adults fed nestlings very infrequently during rain, possibly because of difficulty in foraging (Bovino and Burrt 1979), rainy days were omitted from Figure 1.

Our only method for determining food presented to nestlings was gathering what

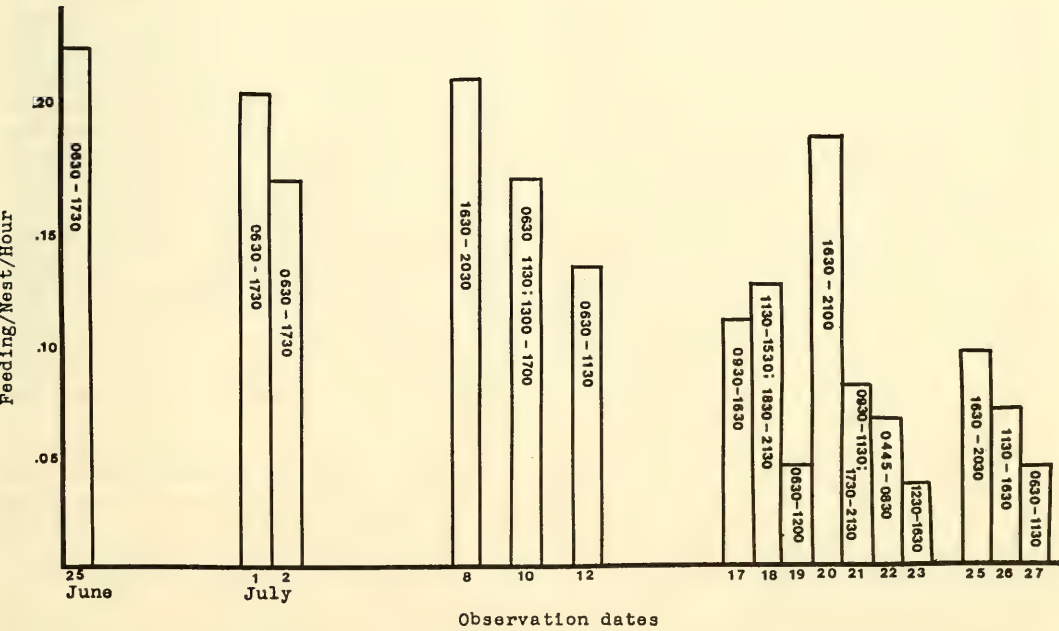


FIGURE 1. Provisioning rates for the 1982 nesting season from 25 June to 27 July at the Basswood Lake heronry. Times of observation for each date appear within each bar.

occasionally fell during a feeding. We found a 30 cm Northern Pike, *Esox lucius*, a 28 cm Smallmouth Bass, *Micropterus dolomieu*, a 15.5 cm Cisco, *Coregonus artedii*, an 11 and a 7.5 cm Yellow Perch, *Perca flavescens*, and a 5 cm Bluegill, *Lepomis macrochirus*. Other fish were found but were partially digested and were unidentifiable. In addition to fish remains, a crayfish claw also was found on the colony floor.

Discussion

The nestling figures (Table 1) are probably slightly higher than actual numbers fledged, because few observations were made during fledging. Fledging rates of approximately 2.0 per nest have apparently allowed this colony to increase after the major decrease in 1965–1968. Henny and Bethers (1971) estimated in western Oregon that 1.91 nestlings per nest must fledge to maintain a stable population.

Mean clutch sizes range from 3.4–5.0 eggs for Great Blue Herons in North America (Bent 1926: 105; McAloney 1973; Pratt 1972, 1974; Quinney 1982, 1983; Vermeer 1969). Quinney (1983) found that between 74 and 80% of all eggs laid hatched, giving initial brood sizes of 2.6 to 3.8 nestlings for North American heronries. As 2.7 nestlings per nest is at the low end of this range, we may have missed some early season mortality. Pratt (1970, 1972) noted that in central California the highest mortality occurred when nestlings were between three and four weeks old. She concluded that mortality occurred at that time because older chicks could swallow whole fish, preventing younger, smaller chicks from receiving any food during a feeding.

We observed no predation, but H. Hadow and D. Lyon (personal communication) both observed predation by Common Ravens, *Corvus corax*, at the Basswood Lake heronry in previous seasons. They saw Common Ravens grasp young nestlings by the neck with their beaks and decapitate them. Common Crows, *C. brachyrhynchos*, Common Ravens, and Bald Eagles also have been described as predators of heron eggs and nestlings (Kelsall and Simpson 1979; McAloney 1973; Quinney 1983). Temple (1969) observed Turkey Vultures, *Cathartes aura*, forcing nestling Great Blue Herons to regurgitate and then feeding this pap to their own young. Turkey Vultures were often seen in the Basswood Lake area, but never in the heronry. If the same harassment occurred there, it could contribute to nestling mortality.

Sibling rivalry may have caused death by direct aggression or indirectly by monopolization of

food. The smallest or youngest nestling often starved or was deprived of food in Grey Herons, *Ardea cinerea* (Owen 1955, 1960), Great Blue Herons (Collazo 1981; Mock 1985; Quinney 1982), Great Egrets, *Casmerodias albus* (Mock 1985), and Snowy Egrets, *Egretta thula* (Jenni 1969).

Mock (1984, 1985) found that Great Blue Heron nestlings in Texas rarely fought during their first month because the single fish presented by adults was too large to be monopolized by small young. Great Egrets, which typically fed many small fish to their young, were used as foster parents to Great Blue Heron broods (Mock 1984). These broods showed significantly more aggression. Sullivan (1986) found that nestling Great Blue Herons in northern Utah which were fed single large fish exhibited less aggression than the herons at Rookery Island. The fish collected during the present study were all relatively small. Herons at Rookery Island may be more aggressive than those in other localities because they depend on smaller fish to feed their young. Nests containing three or four nestlings accounted for 74% of observed aggressive interactions, although 56% of the nests contained one or two young. Less competition probably existed at nests with two young, thus leading to fewer cases of aggression.

Decreased provisioning rates toward the end of the nestling period (Figure 1) may be related to several factors, including: 1) a change from pap to solid food; 2) an increase in the size of fish the nestling can swallow whole; 3) fewer young per nest later in the season; or 4) reduction of nestling body fat to enable flight (Milstein et al. 1979). Temperature was not a limiting factor because the three warmest weeks (weeks 2, 4, and 5 of the study) had both high and low provisioning rates. Mock (1984, 1985) indicated a relationship between fish size and sibling aggression. A change in provisioning rate may indicate a change in food item size. Mock and Parker (1986) also stated that food abundance is probably not an important limiting factor when broods fledge two or three young as in this study.

The Great Blue Heron colony on Rookery Island did not show signs of being affected by acid precipitation. The gradual increase in population after the 1968 nesting season and the adequate number of fledglings during the 1982 nesting season indicated a healthy, stable heronry.

Sibling rivalry was greater at this colony than in other localities. This was most likely a result of a dependence on smaller fish being presented to nestlings, leading to greater competitive aggression among nestmates.

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Diet of the Kelp Snailfish, *Liparis tunicatus*, in Jones Sound, Canadian High Arctic

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Byers, Tim, and R. W. Prach. 1988. Diet of the Kelp Snailfish, *Liparis tunicatus* in Jones Sound, Canadian High Arctic. Canadian Field-Naturalist 102(2): 242-245.

The stomach contents of 65 *Liparis tunicatus* (Kelp Snailfish) specimens from the coast of Colin Archer Peninsula, Devon Island, were analyzed in 1984. The fish, which ranged from 34 to 117 mm in total length, were collected in benthic otter trawls 1.5 m wide in July of 1982 (one only) and 1983 from water depths of between 5 and 15 m. Three of 65 fish stomachs were empty. Crustaceans were the dominant food item in the remainder (99.8% frequency, 99.96% total wet weight). No larval zooplankters were present. The contents of stomachs of *L. tunicatus* collected at the pack-ice edge ($n = 16$) differed significantly from those collected from nearshore open water ($n = 46$). The amphipod *Ischyrocerus anguipes* was abundant in stomachs of the fish from open water, but none occurred in fish from the ice edge. Mysids and all but one cumacean occurred only in fish caught at the ice edge.

Key Words: Kelp Snailfish, *Liparis tunicatus*, diet, Canadian High Arctic.

The Kelp Snailfish, *Liparis tunicatus*, is a kelp-associated, shallow-water, nearshore species which occurs throughout arctic North America from the Bering Strait to the west coast of Greenland. It can be found in tide pools, but is most often brought up in *Laminaria* or *Agarum*-laden trawls, many individuals found still clinging to the fronds by their abdominal sucking discs. Along with *L. fabricii*, *L. tunicatus* is the most northerly *Liparis* species, having been collected as far north as Parr Inlet, Ellesmere Island, at 82°29'N latitude (Able and McAllister 1980).

There are few reports in the literature describing the diet of *L. tunicatus*, and those which exist contain only qualitative information. Amphipods are the main food item mentioned by previous authors (Green and Steele 1977; Collett in Bean 1879). This paper gives a quantitative description of the diet of *L. tunicatus* from off the Colin Archer Peninsula, Devon Island, Northwest Territories.

Study Area and Methods

During the course of marine invertebrate investigations conducted from 1980 to 1984 in western Jones Sound off the Colin Archer Peninsula, Devon Island, Northwest Territories (Figure 1), for a Canadian Wildlife Service (CWS) arctic polynya project, 64 *L. tunicatus* were collected 25 and 26 July 1983, and a single specimen was collected 21 July 1982. All were collected using benthic otter trawls 1.5 m wide. The 1982 sample was taken less than 20 m from

shore (site A) in about 8 m of water. The *L. tunicatus* samples of 25 July 1983 were collected in open water 50-150 m from the Cape Vera

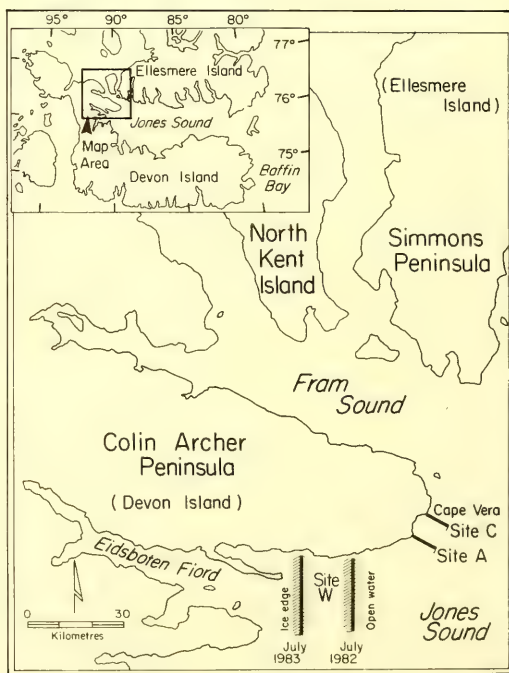


FIGURE 1. Locations (sites A, C and W) of trawls for Kelp Snailfish, *Liparis tunicatus*, in 1982-1983 in the Canadian High Arctic.

TABLE 1. Occurrence, frequency, formalin wet weight and Hynes Point percentages of food items from 62 *Liparis tunicatus* stomachs.

Taxa	% Occurrence n = 62	% Frequency n = 1231	% Formalin Wet Weight n = 4982	Hynes Points n = 963
Crustaceans	100.0 (62)	99.8 (1229)	99.96 (4980)	99.9 (962)
Amphipods	74.2 (46)	36.3 (447)	96.6 (4814)	76.5 (737)
<i>Ischyrocerus anguipes</i>	62.9 (39)	34.2 (421)	82.4 (4103)	66.6 (641)
Lysianassids: total	3.2 (2)	0.4 (5)	2.8 (141)	1.8 (17)
<i>Onisimus glacialis</i>	1.6 (1)	0.2 (2)	1.0 (51)	0.8 (8)
<i>O. littoralis</i>	1.6 (1)	0.2 (2)	1.4 (70)	0.8 (8)
Gammarids: total	3.2 (2)	0.2 (2)	4.7 (235)	1.9 (18)
<i>Gammarus setosus</i>	1.6 (1)	P (1)	4.7 (235)	1.9 (18)
<i>Atylus carinatus</i> (juv.)	1.6 (1)	P (1)	P (< 1)	0.5 (5)
<i>Metopella</i> sp.	3.2 (2)	0.2 (2)	P (< 1)	—
Mysids	6.4 (4)	0.4 (5)	0.4 (21)	0.9 (9)
<i>Mysis littoralis</i>	3.2 (2)	0.2 (2)	0.4 (21)	0.4 (4)
Cumaceans	22.6 (14)	19.5 (240)	1.2 (60)	11.3 (108)
<i>Lamprops fuscata</i>				
Copepods	82.2 (51)	43.6 (537)	0.3 (16)	8.9 (86)
calanoid	3.2 (2)	0.2 (2)	P (< 1)	—
cyclopoid	80.6 (50)	43.5 (535)	0.3 (16)	8.9 (86)
Polychaetes	1.6 (1)	P (1)	P (< 3)	—
Vegetation	1.6 (1)	P (1)	P (2)	0.1 (1)

P = less than 0.1 percent.

Number of stomachs, food items, milligrams or Hynes Points in parentheses.

shoreline (site C) in less than 10 m of water. Those samples from 26 July 1983 were taken from the bottom below the pack-ice edge at West Fjord (site W) between 0.5 and 1 km offshore in less than 15 m of water.

All fish were preserved in 10% formalin immediately upon capture. In the laboratory total length was measured to the nearest 0.1 mm. Total lengths ranged from 34 to 117 mm, inclusive. The fish were dissected and the stomachs removed, slit open, and the contents removed. Hynes Points fullness estimates were allocated to each stomach on a 25-point scale (0 = empty, 10 = half, 20 = full, 25 = distended stomach walls). Organisms were

counted, identified under a dissecting microscope to species whenever possible, air-dried on filter paper for at least five minutes, then weighed to the nearest milligram on a Mettler balance. Final identifications were made by T.B. Identifications were verified at the National Museum of Natural Sciences. Voucher specimens have been retained by the Canadian Wildlife Service in Edmonton, Alberta. Relative portions of the total Hynes Points for a stomach were allocated to each food taxon proportional to the visual estimates of the relative volumes of each. In quantifying the various food taxa, only the cephalothorax of cumaceans or the metasomes of the other broken

TABLE 2. Composition of major food items in stomachs of young-of-the-year and adult (based on total length) *Liparis tunicatus*.

Food taxa	% Occurrence		% Frequency	
	< 40 mm (n = 14)	≥ 40 mm (n = 48)	< 40 mm (n = 264)	≥ 40 mm (n = 967)
<i>Ischyrocerus anguipes</i>	8 (57.1)	31 (64.6)	37 (14.0)	384 (39.7)
Copepods (cyclopoid)	14 (100.0)	36 (75.0)	144 (54.5)	391 (40.4)
<i>Lamprops fuscata</i>	4 (28.6)	10 (20.8)	75 (28.4)	165 (17.1)

and partially digested crustaceans were included in the counts.

Percent occurrence was determined by the number of stomachs containing a given food taxon as a percentage of the total number of stomachs analyzed. Percent frequency was determined by the number of food items of a given taxon in all stomachs as a percentage of the total number of all food items in all stomachs.

Except for a single unidentified polychaete in one stomach, and a piece of terrestrial vegetation in another, crustaceans were the sole constituent of the stomach contents of the specimens examined.

Results

Amphipods and cyclopoid copepods were the most abundant items in the stomachs (frequency of 36.3 and 43.5%, respectively). However, Hynes Point and formalin wet weight percentages indicate an almost exclusively amphipod biomass (Table 1).

Cumaceans were a common food item in less than a quarter of the stomachs (14 of 62). The cumacean, *Lamprops fuscata*, occurred more frequently in the 14 fish less than 40 mm long than in the fish of greater length (Table 2). The smallest fish that took cumaceans or other solely epibenthic crustaceans measured 34 mm in length. These findings indicate that *L. tunicatus* in Jones Sound become benthic at 34 mm in length.

J. Den Beste and P. J. McCart (1978. Nearshore marine fisheries investigations in coastal areas of southeast Baffin Island. Unpublished report by Aquatic Environments Ltd., Calgary for Esso Resources Canada, Limited, Aquitaine Company Canada Limited, and Canada Cities Services Limited, Calgary. 154 pages) report a 34% frequency of copepod nauplii in young of the year (YOY) diet. No larval zooplankters were present in any of the *L. tunicatus* stomachs in our study, although copepod nauplii were present in substantial numbers in zooplankton tows from the fish collection sites.

The most numerous amphipods captured at sites A and C during the study were *Ischyrocerus anguipes*, *Gammarus setosus*, and *Onisimus glacialis*. Except for lysianassids and the one juvenile *Atylus carinatus*, most amphipods in the stomachs examined were from snailfish captured at the nearshore, open-water site (site C; Table 3). *I. anguipes* was a major constituent of the stomach contents of nearshore open-water snailfish, accounting for half of all food items present. Although we found *Lamprops fuscata* inhabiting the sand substrate of a stream discharge in the immediate vicinity of the site C collection site, they were not taken by the *L. tunicata* found there.

No specimen of *T. anguipes* was found in the stomachs of fish captured at the ice edge (West Fjord), although this amphipod was common in

TABLE 3. Food composition differences between *L. tunicatus* caught at ice-edge sites (site W) and nearshore open-water sites (sites A and C).

Taxa	% Occurrence		% Frequency	
	site W n = 16	sites A and C n = 46	site W n = 401	sites A and C n = 830
Amphipods	25.0 (4)	91.3 (42)	3.5 (14)	52.2 (433)
<i>Ischyrocerus anguipes</i>	0	84.8 (39)	0	50.7 (421)
Lysianassids: total	6.2 (1)	2.2 (1)	1.0 (4)	0.1 (1)
<i>Onisimus glacialis</i>	6.2 (1)	0	0.5 (2)	0
<i>O. littoralis</i>	6.2 (1)	0	0.5 (2)	0
Gammarids: total	0	4.3 (2)	0	0.2 (2)
<i>Gammarus setosus</i>	0	2.2 (1)	0	0.1 (1)
<i>Atylus carinatus</i> (juv.)	6.2 (1)	0	0.2 (1)	0
<i>Metopella</i> spp.	0	4.3 (2)	0	0.2 (2)
Mysids	25.0 (4)	0	1.2 (5)	0
<i>Mysis littoralis</i>	12.5 (2)	0	0.5 (2)	0
Cumaceans	81.2 (13)	2.2 (1)	59.6 (239)	0.1 (1)
<i>Lamprops fuscata</i>				
Copepods	87.5 (14)	80.4 (37)	36.4 (146)	47.1 (391)
calanoid	6.2 (1)	2.2 (1)	0.2 (1)	0.1 (1)
cyclopoid	87.5 (14)	80.4 (37)	36.2 (145)	47.0 (391)
Polychaetes	0	2.2 (1)	0	0.1 (1)

the area of the ice edge. For example, 37 *T. anguipes* were brought up in the same trawl as the *L. tunicatus* caught at this site. All cumaceans but one and all mysids were found in the stomachs of fish captured at the ice-edge site. Cyclopoid copepods were found in approximately the same numbers in the stomachs of fish captured in both open water and ice-edge sites.

Discussion

L. tunicatus in western Jones Sound feeds almost exclusively on crustaceans at ice edge and nearshore open water areas during summer. This accords with the observations of Green and Steele (1975) who noted a mostly amphipod diet in June of 1974 and December of 1972. Amphipods, cyclopoid copepods, and cumaceans were the most abundant crustaceans in the stomachs, with amphipods comprising the greatest biomass.

Considerable differences in diet were detected between sampling areas. Open-water fish consumed mostly the common littoral amphipod *Ischyrocerus anguipes* as well as copepods. Fish at the ice edge, however, did not take *I. anguipes* at all, although these amphipods were present there. Instead, they took epibenthic cumaceans, copepods, mysids, and lysianassid amphipods.

At the West Fjord ice-edge site, amphipods were replaced in the diet by the more common, thus more readily available, epibenthic mysids and cumaceans. It should be noted that the otter trawl samples revealed a substantial organic detrital layer at the ice-edge site opposed to the sand/bare rock substrate of the Cape Vera littoral. Thus, the nature of the bottom, rather than the presence of the ice edge, may explain the differences in food items selected by *L. tunicatus* taken from the two areas.

Den Beste and McCart (unpublished: see citation above) state that young-of-the-year *L. tunicatus* (those fish up to 30 to 40 mm in length) from the southeast coast of Baffin Island frequent the water column, while longer fish are benthic. The smallest fish in our sample population, 34 mm in length, consumed epibenthic crustaceans exclusively, indicating that most, if not all, of the fish taken by us were benthic organisms.

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Water Beetles of Some Saline Lakes in Saskatchewan

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Timms, B. V., and U. T. Hammer. 1988. Water beetles of some saline lakes in Saskatchewan. *Canadian Field-Naturalist* 102(2): 246–250.

Thirty-six species of water beetles representing five families were caught in 11 saline lakes (total dissolved solids 3–71 gL⁻¹) in the vicinity of Saskatoon. The most common species were *Enochrus diffusus*, *Gyrinus maculiventris*, *Halipus strigatus*, *Hygrotus salinarius*, *H. tumidiventris* and *Rhantus frontalis*. At least seven species breed in the lakes. Species richness correlated weakly with salinity but strongly with macrophyte abundance. The saline beetle fauna in Saskatchewan is compared with that in Alberta, British Columbia and Australia.

Key Words: water beetles, saline lakes, species richness, Saskatchewan, Dytiscidae, Gyrinidae, Haliplidae, Hydrophilidae, *Enochrus diffusus*, *Hygrotus salinarius*.

Little is known about the water beetles of Saskatchewan, although for adjacent Manitoba the Hydroadephaga have been listed by Wallis (1973) and in Alberta the dytiscid fauna has been well documented by Larson (1975, 1985). In Saskatchewan more interest has been focused on the numerous saline lakes and some authors (Hammer et al. 1975; Rawson and Moore 1944; Swanson 1978; Tones 1976) have listed water beetles. The ecophysiology of the halobiont dytiscid *Hygrotus salinarius*, which is endemic to the Northern Great Plains, has been studied by Tones (1976, 1978). Many other species occur in saline lakes, but data on them are scant.

It is the purpose of this paper to consolidate this information and to combine it with new data on the distribution of aquatic beetles in 11 saline lakes in the vicinity of Saskatoon. From this it will be possible to appraise the variety of beetles and their field salinity ranges in representative saline waters in Saskatchewan. This will then provide a basis for some zoogeographical comparisons.

Methods

Eleven lakes (see Table 1) within a 120-km radius of Saskatoon spanning a salinity range of 3.2 to 71 gL⁻¹ were visited during summer and again in the fall of 1985. Each time 1.5 person-hours were spent searching for water beetles with a pond net. Salinity was measured by determining the total dissolved solids from evaporating a known volume to dryness at 105°C. Since there is little dissolved organic matter in the lakes (Hammer 1978), this method is almost as accurate and much quicker than determining the amount of each ion separately.

In each lake the relative abundance of macrophytes (submerged species as well as littoral emergents) was estimated on a 5-point ordinal scale. Lakes with wide and varied beds of macrophytes were given 4 points, those with narrower beds or fewer species, 3 or 2 points, those with monospecific stands or very limited areas, 1 point, and those without macrophytes scored 0 points. Further information on the macrophytes in the lakes is given in Hammer and Heseltine (1988).

Representative specimens of each taxon were identified by D. Bright (Curculionidae), D. Larson (Dytiscidae, Gyrinidae, Haliplidae) and A. Smetana (Hydrophilidae). Voucher specimens have been deposited in the Limnology Laboratory at the University of Saskatchewan (numbers C1–36).

Results

Thirty-six species from five families (Gyrinidae, Haliplidae, Dytiscidae, Hydrophilidae, Curculionidae) were collected from the 11 lakes (Figure 1). The most frequently collected species were, in descending order, *Enochrus diffusus* (from 9 lakes), *Halipus strigatus* (7), *Hygrotus salinarius* (7), *H. tumidiventris* (7) and *Gyrinus maculiventris* (6). Four species occurred in four lakes, six inhabited two or three lakes and 21 species were found in only one lake each.

Hygrotus salinarius had the widest salinity range (12–71 gL⁻¹), followed by *Enochrus diffusus* (3–49), *Hygrotus tumidiventris* (5–34), *Halipus strigatus* (3–30), and *Gyrinus maculiventris* (5–30) (Figure 1). A further eight species occurred in waters of 20 gL⁻¹ or greater, while 15 species were restricted to waters < 10 gL⁻¹. Most of the species with single or two collection records (20 out of 24) occurred in less saline waters, i.e. < 15 gL⁻¹.

TABLE 1. Total dissolved solids, macrophyte abundance, and the number of beetle species in each lake studied.

Lake*	TDS in gL ⁻¹		Relative macrophyte abundance+	Number of beetle species		
	summer	fall		summer	fall	combined
1. Wakaw	3.2	3.3	4	7	10	13
2. Lenore	5.3	5.6	4	13	9	15
3. Rabbit	7.4	8.8	3	10	4	11
4. Porter	8.0	6.0	1	5	2	5
5. Olivier	12.1	17.7	1	2	1	3
6. Arthur	12.0	21.7	3	11	4	12
7. Redberry	14.0	15.2	2	6	2	7
8. Landis	20.3	34.0	2	10	5	11
9. Sayer	25.0	27.0	2	6	1	6
10. Marie	30.2	49.5	1	2	2	4
11. Haughton	35.0	71.0	0	1	1	1

*See Hammer and Haynes (1978) for limnological information on these lakes.

+4 = wide continuous band of > 8 species of macrophytes around the shore;

3 = band continuous or almost so and 3-6 species contributing;

2 = band discontinuous and 2-4 species present;

1 = discontinuous or isolated clumps of macrophytes; 1-3 species present;

0 = no macrophytes. For more information see Hammer (*In press*).

Larvae were found in most lakes (Table 2). In at least the more saline lakes, the *Hygrotus* larvae were presumably *H. salinarius* or *H. tumidiventris* or both, *Enochrus* larvae were *E. diffusus*, and *Graphoderus* larvae were *G. occidentalis*. Larvae of *Dytiscus*, and to a lesser extent of *Graphoderus* and *Helophorus*, occurred in lakes from which adults were not found.

Generally, species richness was greater in summer than in the fall collections. Five of the common species (*Gyrinus maculiventris*, *Hygrotus impressopunctatus*, *H. patruelis*, *Graphoderus occidentalis* and *Helophorus orientalis*) were restricted, or almost so, to the summer collections, but none of the commoner species were restricted to the fall. The 24 uncommon species occurred equally in summer or fall; of the common group, *Enochrus diffusus* had the most even seasonal distribution pattern.

Species richness tended to decrease with increasing salinity (Table 1), though the only correlation between these two variables that is significant is one between total fauna and average salinity ($r = -0.647$, $P < 0.05$). More striking is the highly significant Spearman's Rank Correlation Coefficient between total fauna and perceived macrophyte abundance ($R = 0.905$; $t = 6.38$; $P < 0.001$).

Discussion

Many aquatic beetles commonly occur in the saline waters (salinity > 3 gL⁻¹) of western

Canada. In Saskatchewan, the present study lists 36 species of 20 genera in 11 lakes; Tones (1976) found 10 genera in six lakes and Swanson (1978) recorded seven species of seven genera in mesosaline Waldsea Lake. In a comprehensive study in Alberta, Larson's (1975, 1985) saline water group contained 13 species in three genera of dytiscids, and Lancaster (1985) noted 17 species of nine genera in five lakes (her other three lakes do not qualify as saline) in inland British Columbia.

The majority of species reported in this study occur widely over the northern Great Plains, the interior of British Columbia, and into the northern Great Basin. In Saskatchewan (Hammer et al. 1975; Rawson and Moore 1944; Swanson 1978; Tones 1976; and the present study) the most common species in saline lakes are (in approximate order of importance) *Hygrotus salinarius*, *Enochrus diffusus*, *Haliphus strigatus*, *Hygrotus* spp. (particularly *H. tumidiventris*), *Rhantus frontalis* and *Gyrinus maculiventris*.

Other genera recorded by more than one author include *Agabus*, *Deronectes*, *Dytiscus*, *Helophorus* and *Laccophilus*. The majority of these occur in species lists for inland British Columbia (Lancaster 1985; Scudder 1969) and Alberta (Larson 1975, 1985). Most species belong to the Dytiscidae and Hydrophilidae, the two major beetle families found worldwide in inland saline waters (Hammer 1986). The Halipilidae, Gyrinidae and Curculionidae are also represented.

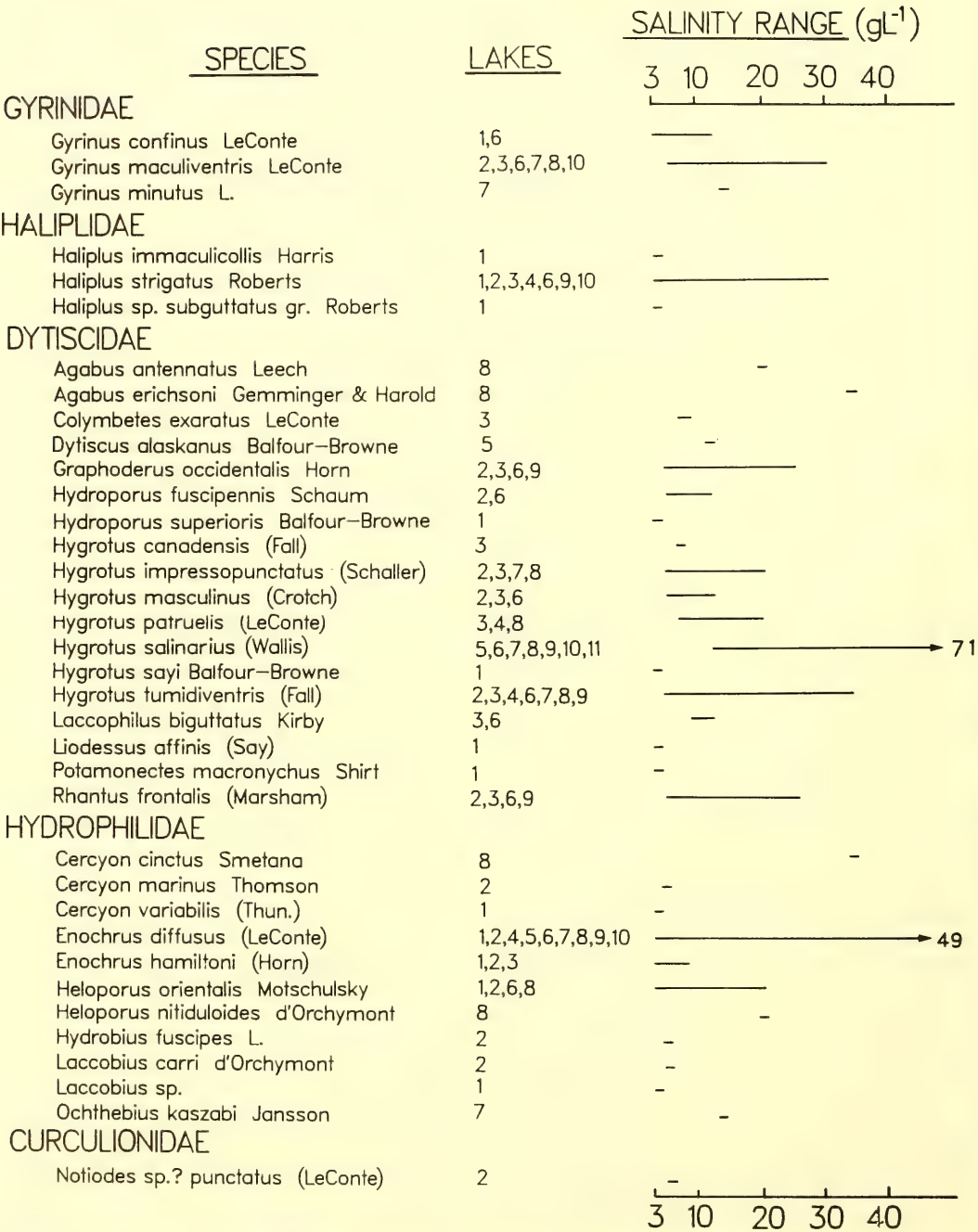


FIGURE 1. Occurrence and field salinity ranges of water beetles in 11 saline lakes around Saskatoon (see Table 1 for code to lakes).

TABLE 2. Beetle larva in the saline lakes.

Lake	<i>Haliphus</i>	<i>Graphoderus</i>	? <i>Dytiscus</i>	<i>Hygrotus</i>	<i>Enochrus</i>	<i>Helophorus</i>	Unident Dytiscid
Wakaw	+		+				+
Lenore		+	+	+		+	
Rabbit		+	+				
Porter		+	+	+		+	
Olivier							
Arthur		+	+	+			
Redberry				+	+		
Landis				+			
Sayer				+			
Marie				+	+		
Haughton							

Much has yet to be learned about field salinity tolerances of the species encountered in this study. The present data combined with those of Tones (1976) and Wallis (1973) suggest that *Enochrus diffusus* has the widest range (0–107 gL⁻¹), followed by *R. frontalis* (0–80), *H. salinarius* (3–71), *H. tumidiventris* (5–34), *Haliphus strigatus* (3–30), *Gyrinus maculiventris* (5–30), *Graphoderus occidentalis* (5–25), and *Helophorus orientalis* (3–20). At least *Enochrus diffusus*, *Hygrotus salinarius* and *Graphoderus occidentalis* are known to breed in mesosaline and hypersaline waters (Swanson 1978; Tones 1976; this study) and so are halophilic, but the other eurysaline species listed above could also be halophilic, given their prevalence in mesosaline waters.

Of the many factors known to influence the distribution and abundance of water beetles (Larson 1985), salinity is one that is hard to prove quantitatively. Salinity and species richness are poorly correlated both in this study and in a similar exercise in Australia by Timms and Watts (1987). Since salinity fluctuates widely in saline lakes of the prairies (Liefvers and Shay 1983), extreme fluctuations may control species distributions, but this was not examined here because of insufficient data on such fluctuations in these lakes.

Such fluctuations could possibly contribute to the ordination of species along a salinity gradient being different in adjacent areas. An example is provided by *Hygrotus* — in Alberta Larson (1985) recorded the order, from greatest to least salinity

TABLE 3. Taxonomic composition of saline lake beetle faunas.

Taxa	Oldesloe Europe	Near Saskatoon, Canada	Near Colac, Australia
Sphaeriidae	—	—	1
Gyrinidae	—	3	—
Haliphiidae	—	3	—
Dytiscidae	7?	20	10
Hydrophilidae	20	12	8
Curculionidae	2	1	—
Others	1	—	—
Total	30?	39	19
Numbers of species in waters > 10 gL ⁻¹		24	12
> 20 gL ⁻¹		17	5
> 30 gL ⁻¹		8	4
> 40 gL ⁻¹		3	2
> 100 gL ⁻¹		1	—
Source	Benick (1926))	Swanson (1978) Tones (1976) This study	Timms & Watts (1987)

tolerance of *salinarius* > *masculinus*... > *tumidiventris*... > *patruelis* = *canadensis* > *impressopunctatus*... > *sayi* whereas the order in the present study is *salinarius* > *tumidiventris* > *impressopunctatus* = *patruelis* > *masculinus* > *canadensis* > *sayi*. However, this difference could at least be partly explained by the different range of habitats examined in the two studies — e.g. Larson (1985) included temporary salinas in which *H. masculinus* is common, and thus gave it a more elevated rating than in the present study. Also, freshwater habitats were not sampled, perhaps further distorting any ordination.

On the other hand, Timms and Watts (1987), Tones (1976) and this study point to the importance of aquatic macrophytes in influencing distribution and abundance of water beetles. In the present case the relationship is seen in a comparison of pairs of lakes with similar salinities but different relative abundances of macrophytes (e.g. Arthur and Olivier lakes and Rabbit and Porter lakes — Table 1) and in the highly significant correlation between macrophyte abundance and species richness. The conclusion by Hammer (1986) that water beetles in saline lakes are “influenced more by vegetation than by salinity which is more important at the extremes of the salinity range” is thus appropriate.

Finally, compared to other parts of the world for which comparative data are available, the saline lake fauna of Saskatchewan is perhaps as diverse as that of the Oldesloe area in Europe, but is much richer than the fauna in lakes in Victoria, Australia (Table 3). The main differences between Saskatchewan and Victoria lie in the greater variety of species in mesosaline and hyposaline waters and in more families being represented in the Saskatchewan study. As expected, no species is common to the two areas, but the genera *Enochrus*, *Liodessus* and *Rhantus* are.

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Notes

Southern Range Extension of the Dusky Rockfish, *Sebastes ciliatus*, in British Columbia

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Richards, Laura J., and S. Jergen Westrheim. 1988. Southern range extension of the Dusky Rockfish, *Sebastes ciliatus*, in British Columbia. *Canadian Field-Naturalist* 102(2): 251–253.

Morphometrics and meristics are presented for one Dusky Rockfish, *Sebastes ciliatus*, specimen captured 19 June 1986 at the north end of Johnstone Strait (52°36'N, 126°48'W). This extends the southern range by 191 km. *S. ciliatus* account for 6% of the sport rockfish catch in the area.

Key Words: *Sebastes ciliatus*, Dusky Rockfish, British Columbia, distribution, meristics.

During a study of the commercial handline rockfish fishery, we caught two specimens of Dusky Rockfish, *Sebastes ciliatus*, near the northern entrance to Johnstone Strait. Both were caught using sport angling gear and 12-cm frozen bait herring. The first, 233 mm standard length (273 fork length), was caught on 19 June 1986 near the Plumper Islands (50°36'N, 126°48'W) at a maximum depth of 63 m and has been deposited in the British Columbia Provincial Museum (catalogue number BCPM 986-149). The second specimen was caught on 26 June 1986 near Pearse Reefs (50°36'N, 126°51'W) at a maximum depth of 37 m. In addition to the second Dusky Rockfish, five Yellowtail Rockfish, *S. flavidus*, four Quillback Rockfish, *S. maliger*, two Black Rockfish, *S. melanops*, one Kelp Greenling, *Hexagrammos decagrammus*, and one Lingcod, *Ophiodon elongatus*, were also caught during 90 minutes of fishing at that site.

The northern limit of Dusky Rockfish is the Bering Sea (Okada and Kobayashi 1968). Westrheim (1973) described the southern limit as Dixon Entrance (54°13'N, 132°42'W), based on trawl catches (Westrheim 1968). Peden and Wilson (1976) extended the range southward into Hecate Strait to between 52°18.6'N, 130°29.2'W and 52°20.4'N, 130°27.7'W. Our specimens therefore represent a 191-km extension of the known range. Peden and Wilson (1976) based their results on five large specimens (360–382 mm standard length) collected by trawl at a depth of 185–199 m (Westrheim et al. 1974). They also presented the

meristics for 17 smaller specimens (82–220 mm standard length) they collected within SCUBA depth (21 m) in north coastal British Columbia near 54°N.

Seeb (1986) has suggested that the species Dusky Rockfish includes two sister species. To avoid confusion between each form, morphometric and meristic data for the first specimen are reported in Tables 1 and 2, in the format of Phillips (1957). Morphometric measurements were collected after the frozen specimen had thawed. The ratios are all within ± 0.1 of the ratios reported by Westrheim (1973), and the meristic counts and other morphological characteristics are similar or identical. The ratios are more consistent with the measurements of the small inshore specimens reported by Peden and Wilson (1976) than with the large specimens from Hecate Strait.

The second specimen was not preserved. It was a mature male, measured 366 mm fork length and weighed 0.8 kg. We also observed six Dusky Rockfish that were landed at the marina in nearby Telegraph Cove by sport fishermen and apparently caught in inshore waters at relatively shallow depths. Dusky Rockfish accounted for 6% ($n = 107$) of the sport-caught rockfish we examined during 16–26 June 1986. These fish represented both sexes and had a mean fork length of 367 mm with a range of 258–455 mm. They were similar in size to the fish caught by trawl in Hecate Strait (Westrheim 1973), and were larger than the fish collected by Peden and Wilson (1976) in the inshore waters of northern British Columbia.

TABLE 1. Morphometric ratios and meristic counts for one Dusky Rockfish specimen.

Measurement	Frequency of measurement into:		Frequency of orbit width into:
	Standard length	Head length	Measurement
Head length	3.1	—	4.2
Body depth at pelvic fin origin	3.1	1.0	4.2
Body depth at anal fin origin	3.5	1.1	3.7
Length of anal fin base	6.7	2.1	1.9
Snout length	12.9	4.2	1.0
Orbit diameter	12.9	4.2	—
Interorbital width	12.9	4.2	1.0
Suborbital width	38.8	12.5	0.3
Upper jaw length	6.9	2.2	1.9
Amount lower jaw projects	38.8	12.5	0.3
Body thickness	7.1	2.3	1.8
Length of pectoral fin base	10.6	3.4	1.2
Longest pectoral fin ray	3.6	1.2	3.6
Longest pelvic fin ray	5.2	1.7	2.5
Length of pelvic fin spine	8.0	2.6	1.6
Length of first anal fin spine	21.2	6.8	0.6
Length of second anal fin spine	10.1	3.3	1.3
Length of third anal fin spine	9.0	2.9	1.4
Longest anal fin ray	5.2	1.7	2.5
Longest dorsal fin spine	7.5	2.4	1.7
Longest dorsal fin ray	6.5	2.1	2.0
Depth of caudal peduncle	10.1	3.3	1.3
Ventral length of caudal peduncle	4.9	1.6	2.7
Dorsal length of caudal peduncle	6.9	2.2	1.9
Distance from anal fin to anus	21.2	6.8	0.6
Longest raker on first gill arch	17.9	5.8	0.7
Number of spines and rays in dorsal fin	XIII, 17		
Number of spines and rays in anal fin	III, 9		
Number of rays in each pectoral fin	18/18		
Unbranched rays in each pectoral fin	9/9		
Number of gill rakers on first arch	32		
Number of pores in lateral line	47		
Diagonal scale rows below lateral line	51		
Fork length	273 mm		
Standard length	233 mm		

Acknowledgments

Thanks to Dr. Alex Peden for reviewing the manuscript.

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TABLE 2. Other morphological characteristics of one Dusky Rockfish specimen.

Sex: male.
Body color: near black; belly white, edged with pink.
Mouth and gill cavities: white.
Peritoneum: black.
Top of head at midorbits: slightly convex.
Spines on top of head: weak nasal, preoculars and superoculars.
Parietal ridges: weakly apparent.
Five preopercular spines: radially directed; moderately strong; upper two directed backward.
Two opercular spines: moderately strong and sharp; upper one longer and more prominent.
Supracleithral and cleithral spines: moderately strong and sharp; roughly equal in length.
Lower margin of suborbital bone: without spines.
Lower posterior edge of gill cover: two weak spines.
Symphyseal knob: present, moderate.
Raised patch of teeth on tip of lower jaw: distinct patch, moderately elevated.
End of maxillary: to rear of pupil.
Maxillaries: covered with scales.
Mandibles: covered with scales.
Branchiostegals: covered with scales.
Ends of pectoral and pelvic fins: pectorals extend slightly past pelvics to reach anus by less than one orbit diameter.
Second anal fin spine: twice as thick as third; shorter than third when depressed.
Spinous dorsal fin membrane: moderately incised.
Posterior profile of caudal fin: slightly indented.
Terminal profile of anal fin: slight anterior slant.

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The Wandering Shrew, *Sorex vagrans*, in Alberta

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Provincial Museum of Alberta Natural History Contribution 94.

Smith, Hugh C. 1988. The Wandering Shrew, *Sorex vagrans*, in Alberta. Canadian Field-Naturalist 102(2): 254–256.

Seven specimens of the Wandering Shrew, *Sorex vagrans*, were collected in the West Castle area of southwestern Alberta. This constitutes the first record of this species east of the continental divide and the first record for Alberta.

Key Words: Wandering shrew, *Sorex vagrans*, first record, Alberta.

In August 1982 the Provincial Museum of Alberta conducted a small mammal survey in the West Castle area of southwestern Alberta. Among the ninety-one specimens collected were thirteen identified as *Sorex monticolus*.

Recently, while examining the *Sorex monticolus* collection in the Provincial Museum of Alberta, I found seven specimens that showed characteristics of *Sorex vagrans*. These seven specimens were part of the thirteen "*Sorex monticolus*" specimens collected in the West Castle survey (Table 1). In order to verify the identification, six specimens were forwarded to C. G. van Zyll de Jong of the National Museum of Natural Sciences in Ottawa. Dr. van Zyll de Jong confirmed that the specimens in question were *Sorex vagrans*. This species has not previously been reported east of the continental divide (Hall 1981; Hawes 1977; Hennings and Hoffmann 1977; Junge and Hoffmann 1981; van Zyll de Jong 1983) and constitutes a species new to Alberta.

There is a great deal of confusion over the names applied to this species-complex, especially for those found in Alberta. For example, Soper (1964) used the name *Sorex vagrans obscurus* for those shrews of this group found in Alberta. He was using the taxonomy of Findley (1955). Hall (1981) also used this name for these shrews. Banfield (1974), on the other hand, used the name *Sorex obscurus* for those animals found in northern British Columbia and western and northern Alberta. He used the name *Sorex vagrans* for those animals found in southern British Columbia. Hennings and Hoffmann (1977) reviewed the *Sorex vagrans* complex of western North America and concluded that two species were identifiable: *Sorex vagrans* and *Sorex monticolus*. Like Banfield (1974), Hennings and Hoffmann (1977) used the name *Sorex vagrans* for those animals found in southern British Columbia, Washington, Oregon, northern California and Nevada, western

and northern Idaho, and western Montana. The name *Sorex monticolus* was used, on the basis of priority, for the more widespread form. According to these authors the subspecies found in Alberta is *Sorex monticolus obscurus*.

Externally *Sorex monticolus* and *Sorex vagrans* are difficult to tell apart; however, several characters have been found that are useful in separating the two species. For example, Hawes (1976) found that breeding males of the two species could be distinguished from each other on the basis of odor. Van Zyll de Jong (1982) pointed out that the hind feet of *Sorex vagrans* were shorter than those of *Sorex monticolus*. He also found that the number of callosities, or friction pads, on the hind toes II to IV are fewer in *Sorex vagrans* (four) than in *Sorex monticolus* (more than four). The character I used to determine the species from the West Castle area was that of Hennings and Hoffmann (1977). The medial tines on the upper incisors of *Sorex vagrans* are relatively small and barely reach the dark orange pigmentation on the front of the incisors, whereas these tines in *Sorex monticolus* are large and extend well into the orange pigmentation. It was found that this character was reliable for all specimens except very old individuals with extremely worn incisors.

When compared to a larger sample of *Sorex monticolus* from other areas of Alberta, it was found that *Sorex vagrans* from West Castle were significantly smaller in all but one cranial or external measurement (Table 2).

Hawes (1977) found that where the two species occur sympatrically, *Sorex monticolus* prefers more acidic conditions, whereas *Sorex vagrans* prefers a richer soil. In the West Castle survey, specimens of each species were collected on the same trapline; unfortunately field notes made at the time do not describe the habitat surrounding the trap sites. It is not possible, therefore, to provide any information on habitat preferences in Alberta.

TABLE 1. Trapping localities, species list, and numbers of specimens of small mammals trapped in small mammal survey in West Castle area, Alberta, August 1982.

	49° 16'N 114° 16'	49° 16'N 114° 22'	49° 17'N 114° 24'	49° 17'N 114° 26'	49° 19'N 114° 25'	49° 19'N 114° 24'
Masked Shrew (<i>Sorex cinereus</i>)			1	1		2
Dusky Shrew (<i>Sorex monticolus</i>)		1	2		2	1
Wandering Shrew (<i>Sorex vagrans</i>)		1			3	3
Water shrew (<i>Sorex palustris</i>)		2				
Yellow-pine Chipmunk (<i>Tamias amoenus</i>)						1
Deer Mouse (<i>Peromyscus maniculatus</i>)	1	2	4	8	2	6
Southern Red-backed Vole (<i>Clethrionomys gapperi</i>)						1
Heather Vole (<i>Phenacomys intermedius</i>)		3				1
Meadow Vole (<i>Microtus pennsylvanicus</i>)	1		1		8	15
Long-tailed Vole (<i>Microtus longicaudus</i>)		2	5			2
Western Jumping Mouse (<i>Zapus princeps</i>)			2		3	9

Pruitt (1954) used a method of tooth wear for placing *Sorex cinereus* into age groups. Age Group 1 is the youngest with little or no tooth wear, Age Group 4 the oldest with extensive tooth wear. Age Groups 2 and 3 are between these extremes. Using this method to age the samples of *Sorex vagrans* and *Sorex monticolus* collected at West Castle, *Sorex vagrans* can be placed in the following age categories: Age Group 1 (five specimens), and Age Group 2 (2 specimens). Six of these specimens are females and one sex not determined. Specimens from the *Sorex monticolus* sample are assigned to the following groups: Age Group 1 (one specimen), Age Group 2 (three specimens), Age Group 4 (two specimens). Three specimens are females, two are males, and one sex not determined.

The discovery of a population of *Sorex vagrans* east of the continental divide opens several questions that are not answerable by the small sample reported here. For example, the age structure of the *Sorex monticolus* sample contained both young and old individuals and the sex ratio of this sample was almost 1:1. In the *Sorex vagrans* sample only young were caught and all but one were females.

Are these artifacts of trapping methods? Hennings and Hoffmann (1977) pointed out that *Sorex vagrans* occupies riparian habitats in western Montana and appears limited by high

altitude, dry soils, and boreal forests. For these reasons, these authors believed the continental divide limits the eastward expansion of the range of *Sorex vagrans*. If these limitations are real, the routes open to invading individuals are not known, as all the passes between southeastern British Columbia and northwestern Montana to southwestern Alberta are at relatively high elevations with intervening boreo-montane forests. Van Zyll de Jong (1983) reports specimens from Morrissey, British Columbia. Morrissey is on the Elk River and this river comes near Crowsnest Pass. This pass has an elevation of 1370 metres, possibly low enough to be a pathway for *Sorex vagrans*.

At this time, no assessment of the abundance and distribution of *Sorex vagrans* in Alberta can be made. In the sample of small mammals collected in the West Castle area, *Sorex vagrans* made up eight per cent of the specimens caught (Table 1). The species was also taken at three localities separated from each other by several kilometres.

Acknowledgments

I wish to acknowledge the assistance given to me by Bruce McGillivray, James Burns, and William Weimann, as well as C. G. van Zyll de Jong who confirmed my identifications as well as commented on an early draft of this paper.

TABLE 2. Selected external and cranial measurements of *Sorex monticolus* and *Sorex vagrans*. The *Sorex monticolus* are from various areas of Alberta; the *Sorex vagrans* are from the West Castle area. The measurements are according to Junge and Hoffmann (1981).

		<i>Sorex monticolus</i>	<i>Sorex vagrans</i>
		n = 24	n = 6
Total Length	$\bar{x}$	105.9*	100.2*
	SD	5.89	6.08
	R	94-120	92-110
Tail	$\bar{x}$	45.2	46.0
	SD	2.57	5.02
	R	42-50	42-56
Condylbasal Length	$\bar{x}$	17.27**	16.75**
	SD	0.37	0.14
	R	16.19-17.93	16.65-16.97
Rostrum Length	$\bar{x}$	7.37**	6.65**
	SD	0.28	0.14
	R	6.61-7.80	6.38-6.77
Interorbital Breadth	$\bar{x}$	3.36**	3.10**
	SD	0.09	0.17
	R	3.21-3.51	2.80-3.26
Maxillary Tooththrow Length	$\bar{x}$	6.52**	6.14**
	SD	0.18	0.09
	R	6.03-6.76	6.01-6.29
Cranial Breadth	$\bar{x}$	8.67*	8.39*
	SD	0.23	0.14
	R	8.15-9.14	8.18-8.58

*Means significantly different at $P < .05$, t -test

**Means significantly different at $P < .001$, t -test

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First Breeding Record of the Dunlin, *Calidris alpina*, on Baffin Island, Northwest Territories

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Martin, Jean-Louis, Alex Clamens, and Sylvie Blangy. 1988. First breeding record of the Dunlin, *Calidris alpina*, on Baffin Island, Northwest Territories. *Canadian Field-Naturalist* 102(2): 257–258.

We report a nest with four eggs and incubating adult Dunlin (*Calidris alpina*) observed 16 July 1986 during a four week stay in southwestern Baffin Island. Although the species has been previously reported from this island, nesting had not been confirmed.

Key Words: Dunlin, *Calidris alpina*, breeding record, Baffin Island.

The Dunlin (*Calidris alpina*) is a well-studied wader (e.g. Holmes 1966a; Soikkeli 1967) with a northern circumpolar distribution. Its breeding habitat in the northern part of its breeding range consists mainly of wet tundra (see Holmes 1966b). The species' distribution in north-eastern Canada was given by Voous (1960), Glutz von Blotzheim and Bauer (1975), Cramp and Simmons (1983), Hayman et al (1986) and Godfrey (1986). The species was noted as absent as a breeder on Baffin Island by all these authors, although Godfrey mentioned its presence in summer on southwestern Baffin Island (Bowman Bay area) based on records of Soper (1940, 1946). The latter author managed to collect two individuals in June and July 1929 but did not detect any sign of breeding Dunlin. He also mentions that local Inuits did not have any native name for the bird.

In 1986 we had the opportunity to stay four weeks on southwestern Baffin. From 4 to 18 July we visited the area around the Bluegoose river headwaters (65°35'N, 72°30'W), east of the Great Plain of the Koukdjuak (Figure 1). In this area we verified Dunlins' breeding. They seemed to occur there in all places where habitat was suitable.

Figure 1 shows the area effectively covered by our observations, and the locations where Dunlins were observed. Most of the birds were concentrated in areas 1 and 2 (Figure 1) where suitable habitat (wet grassy tundra) was most abundant. Area 1 situated at the edge of the Koukdjuak plain, was very marshy at that time of the year, and the landscape was dotted with many small lakes and ponds. Area 2, much smaller, was a marshy floodplain on the shore of a lake. Between these two sites, Dunlins were observed only in the small patches of marshy tundra scattered along the river valley or near small lakes.

On site 1, where we stayed between 9 and 13 July the late evenings (from approximately 21:00 to 24:00) were made memorable by the territorial songs of the Dunlins. The birds were answering each other; this indicated the presence of a structured population of territorial birds. Our rather crude density estimates (1 pair for 5–8 ha) are consistent with the published figures (Glutz von Blotzheim and Bauer 1975; Holmes 1966b, 1970; Cramp and Simmons 1983).

Several attempts were made to follow individual birds with binoculars in order to locate nests but only one was successful: on July 16 a nest with four eggs and an incubating adult was found.

It appears that the Dunlin should be considered as a breeder on southwestern Baffin Island. From our experience and in the area visited, it was one of the three most commonly sighted sandpipers with an overall abundance higher than that of the Bairds' sandpiper (*C. bairdii*) and lower than that of the White rumped sandpiper (*C. fuscicollis*). In the absence of long term data the year to year regularity or the novelty of the observed pattern remains, however, an open question.

Acknowledgments

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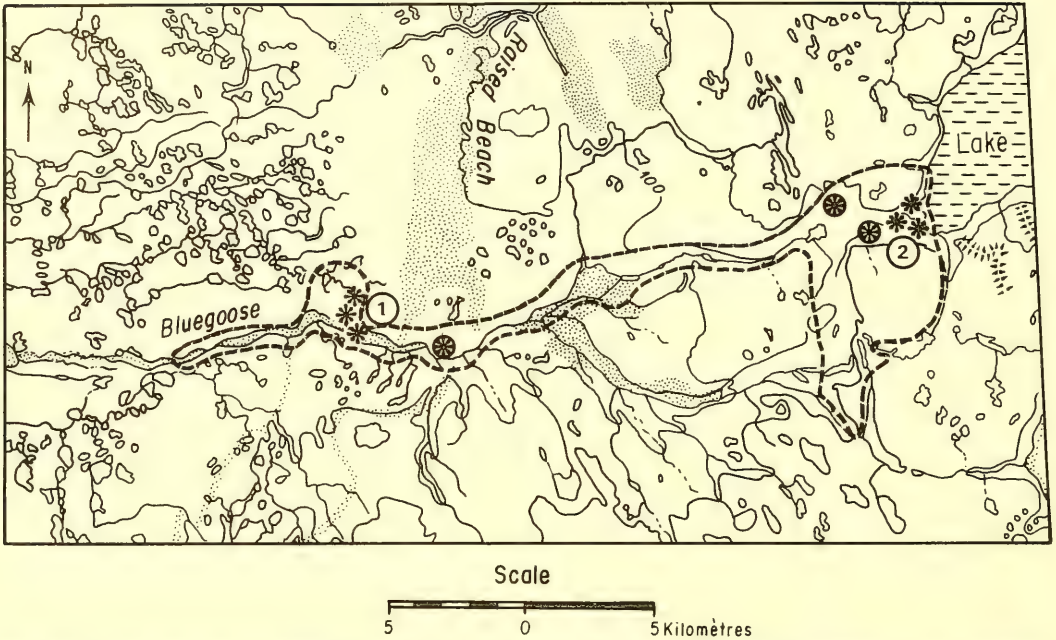


FIGURE 1. The area visited on Baffin Island and the location of the Dunlin observations. Elevation varied from 60 to 170 m. Stars = isolated individuals; circled stars = groups of territorial individuals; dotted line = area effectively explored; circled numbers defined in the text.

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Persistent Attempts by a Male Calliope Hummingbird, *Stellula calliope*, to Copulate with Newly Fledged Conspecifics

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Armstrong, Doug P. 1988. Persistent attempts by a male Calliope Hummingbird, *Stellula calliope*, to copulate with newly fledged conspecifics. *Canadian Field-Naturalist* 102(2): 259–260.

I describe apparent attempts by an adult male Calliope Hummingbird to court and copulate with two recently fledged conspecifics on 4–7 July 1984.

Key Words: Hummingbirds, *Stellula calliope*, misdirected courtship, breeding behavior, copulation.

At my study site in southern British Columbia (49° 18' N, 119° 47' W; see Armstrong (1987) for further details), I observed several interactions between an adult male and two fledgling Calliope Hummingbirds, *Stellula calliope*. Two offspring of an individually marked female fledged on or slightly before 2 July 1984 when I first saw them being fed by the female in a clearing about 30 m from their nest site.

The first interaction I observed occurred from 1215 h to 1218 h on 4 July. The male performed a dive display (Tamm 1985) consisting of five U-shaped dives directly over the bush on which the fledglings were perched, and then descended so that he was directly facing one of the fledglings at a distance of 20 cm. In this position, he made a loud “buzzing” sound with his wings for two seconds [this may be similar to the “shuttle display” described by Stiles (1982)], backed to 50 cm from the fledgling, and hovered silently for three seconds. He then buzzed, hovered, buzzed again, and quickly flew around to the back of the fledgling. The fledgling responded by turning on its perch so that it remained facing the male. The male twice more flew around the fledgling, and the fledgling each time turned so that it remained facing the male. The fledgling further tracked the movements of the male by moving its head so that its bill was always pointed directly at the male. Stiles (1982) observed adult female Anna’s Hummingbirds, *Calypte anna*, performing similar bill-pointing behavior while being courted by males.

After sitting on a nearby perch for 12 seconds, the male did a series of four dives, buzzed twice directly in front of the second fledgling, then flew around and behind it three times in succession. This fledgling also turned to face the male each

time, and after the third time, flew off its perch with its beak thrust forward as if to strike the male. The male flew upward, did one dive, and then buzzed in front of the first fledgling. He immediately flew around behind it, the fledgling turned to face him, and the male buzzed once more. At this point, the fledglings’ mother returned and chased the male away.

I observed several similar interactions later on 4 July as well as on 5, 6, and 7 July, after which the fledglings and their mother disappeared from the area. Because a male was in the area throughout the four days and almost always used the same perch, I assume that all these observations were of one male who may have had a territory there.

I believe the behavior of this male toward the fledglings was attempted courtship and copulation rather than aggression. Territorial Calliope Hummingbird males occasionally direct both dive and buzzing displays towards other adult males, but these displays occur much more frequently when they are interacting with breeding females (Armstrong 1986; Tamm, et al. *in press*). It is also common for males to dive at passerine birds on their territories (Tamm 1985), but I have never observed males perform repeated buzzing displays with passerines or attempt to approach them from behind. Aggressive interactions between Calliope Hummingbird males are generally concluded by the territory owner chasing away the intruder. Given that the fledglings were inexperienced and poor fliers, it is unlikely that the male would have had any difficulty expelling them from the area had he been attempting to do so. In all the interactions I observed between the male and the fledglings, however, he never attempted to drive a fledgling from its perch.

Stiles (1982) observed an adult male Anna's Hummingbird apparently attempt to copulate with a juvenile male, and male hummingbirds have been observed performing the motions of copulation over dead leaves and branches (Snow 1974; Stiles and Wolf 1979; personal observations). "False matings" (Snow 1974) with dead leaves or branches are brief, and are unlikely to have a significant cost to males in terms of time or energy. It is also unlikely that males mistake these objects for females, and this behavior might simply be "practice" for future matings. Copulation attempts with juvenile conspecifics are more likely both to be true mistakes and to involve a significant cost. The behavior sequence described by Stiles (1982) lasted several minutes, during which time the male chased, sang to, displayed to, knocked down, and attempted to mount the juvenile.

Given that the male I observed persisted for four days in his attempts to copulate with the fledglings, he could have invested a significant amount of his time and energy in this behavior. This behavior was not only apparently misdirected, but also took place so late in the season that it is unlikely that a female inseminated at that time could have successfully raised a clutch. Of seven nests found in this area in 1983 and 1984, only one contained eggs in July, and that nest was subsequently abandoned.

I suspect that this apparently maladaptive behavior may occur simply because it isn't costly enough or doesn't occur frequently enough for natural selection to favor more discriminating males. Juveniles and females are very similar in appearance, and it may be difficult for males to distinguish them. In promiscuous breeders such as hummingbirds, the advantages males gain from

additional matings may be so great that they would not benefit by ensuring that courtship and copulation attempts were directed only towards receptive females.

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European Frog-bit, *Hydrocharis morsus-ranae*, in Lake Ontario Marshes

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Lumsden, Harry G., and David J. McLachlin. 1988. European Frog-bit, *Hydrocharis morsus-ranae*, in Lake Ontario marshes. Canadian Field-Naturalist 102(2): 261-263.

Hydrocharis morsus-ranae is newly reported from eight western Lake Ontario marshes. It was not found in this region in various botanical surveys conducted throughout the 1970s, and probably arrived in the region at about the time of its discovery there in 1982.

Key Words: European Frog-bit, *Hydrocharis morsus-ranae*, spread, Lake Ontario.

The introduction of the European Frog-bit, *Hydrocharis morsus-ranae*, at Ottawa in 1932 and its subsequent spread to the Rideau Canal were reported by Minshall (1940). Dore (1954, 1968) further documented its spread in Ontario to the Ottawa River, reviewed its colonization of Quebec rivers and reported its presence upstream from Ottawa in the Rideau Canal.

Dore (1968) pointed out that the Rideau Canal, which connects Ottawa with Kingston on Lake Ontario, "... presents a system very susceptible to the rapid spread of aquatic plants".

Catling and Dore (1982) recorded the spread of *Hydrocharis morsus-ranae* throughout the Rideau canal system, the lower Ottawa River, the entire St. Lawrence, and in eastern Lake Ontario including marshes in Prince Edward County and at Presqu'île Bay near Brighton. They also reported an isolated station at Rondeau Park on Lake Erie.

European Frog-bit was not found during recent botanical surveys of western Lake Ontario marshes including, for example, Riley's (1978) survey of the Rouge marsh. Although Catling collected *H. morsus-ranae* in the western Lake

TABLE 1. Occurrence of European Frog-bit in 20 marshes adjacent to Lake Ontario.

	Specimen collected	Not found
Port Darlington, Bowmanville 43°54'N 78°40'W	x	
St. Mary's marsh, Bowmanville 43°54'N 78°41'W	x	
Cement Plant marsh, Bowmanville 43°53'N 78°42'W		x
McLaughlin Bay, Darlington Provincial Park 43°52'N 78°48'W		x
Second marsh, Oshawa 43°52'30"N 78°49'W		x
Oshawa Filtration Plant 43°51'30"N 78°50'W		x
Thickson Road Filtration Plant, Oshawa 43°51'30"N 78°53'30"W	x	
Whitby Harbour 43°51'N 78°56'W		x
Lynde Creek marsh, Whitby 43°51'N 78°57'30"W	x	
Cranberry marsh, Whitby 43°50'30"N 78°58'W		x
Shoal Point marsh, Richardson's Point 43°50'45"N 78°59'W	x	
Duffin's Creek mouth 43°49'N 79°02' N		x
Pickering Hydro marsh 43°49'N 79°04'30"W	x	
Frenchman's Bay, Pickering 43°49'N 79°05'W	x	
Rouge River mouth 43°48'N 79°07'W	x	
Tommy Thompson Park (Leslie Street Spit) 43°38'N 79°20'W		x
Ratray marsh, Port Credit 43°30'30"N 79°36'30"W		x
Hamilton harbour 43°16'30"N 79°53'30"W		x
Pond near Royal Botanical Gardens 43°17'30"N 79°43'W		x
Cootes Paradise, Dundas 43°16'N 79°55'30"W		x

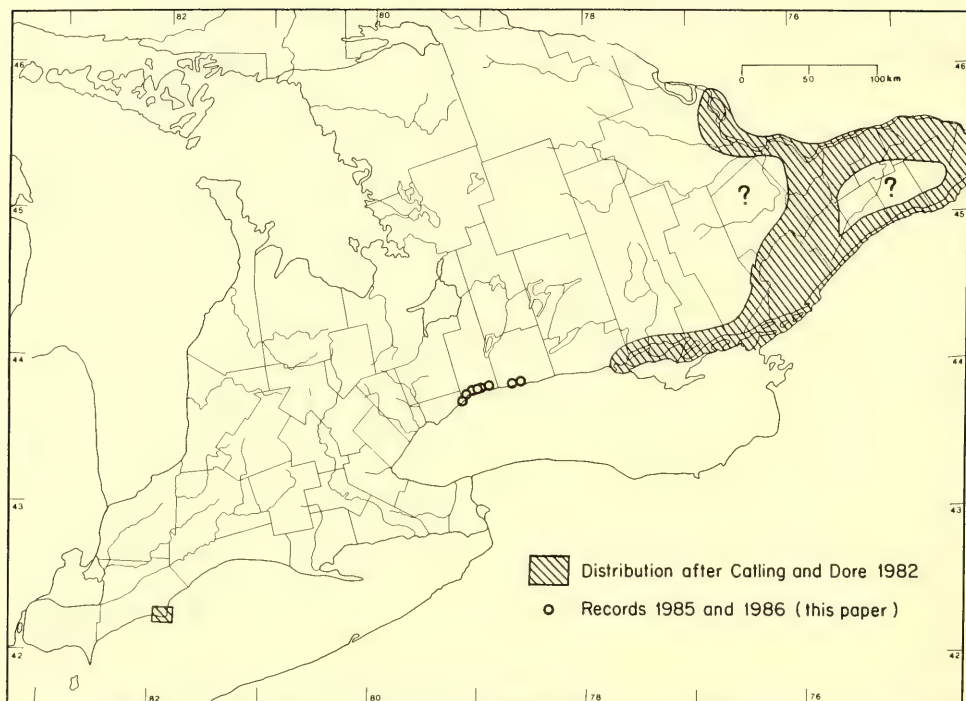


FIGURE 1. The distribuion of *Hydrocharis morsus-ranae* in eastern Ontario.

Ontario region in 1982 at Lynde Creek (at the site where we found it in 1985), this was not in time to be included in his paper (Catling and Dore 1982). Since botanists were active in the area, the first record in 1982 at Lynde Creek probably closely approximates its actual time of arrival in the region.

We first found frog-bit in the Shoal Point marsh on Richardson Point on 23 August 1985. In 1986 20 Lake Ontario marshes between Port Darlington, Bowmanville, and Cootes Paradise, Dundas, were checked for the presence of frog-bit; we found the species, often abundant, in eight (Table 1 and Figure 1).

We found most colonies of frog-bit growing within stands of cattail (*Typha* sp.). The floating leaves of frog-bit formed a sparse-to-dense cover on the surface of the water. In September 1985 we found turions floating along the shores of Lynde Creek outside the stands of cattail.

Dore (1968) suggested that pleasure boat traffic would account for the gradual spread of frog-bit through the locks of the Rideau system. Dense

mats readily tangle on the shaft of outboard motors. Currents and winds have probably also carried the floating turions. Dispersal of plant parts, including vegetative buds and seeds, by waterfowl may also be important (Catling and Dore 1968).

The occurrence of frog-bit in western Lake Ontario was patchy in 1986, and it is not easy to account for its erratic distribution. Frog-bit was absent from the Cement Plant marsh, the Oshawa Filtration Plant marsh and Cranberry marsh. Absence in these areas is probably a result of chance: the plants are apparently still spreading and will probably colonize these areas. Its absence west of the Rouge River apparently marks the limit of its westward spread in Lake Ontario at this time.

Acknowledgments

We are grateful to John Riley for identifying specimens, and to Paul Catling for comments and suggestions on this note. Specimens have been placed in the herbarium at the Central Experimental Farm, Agriculture Canada, in Ottawa.

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A Disjunct Population of the Blue-spotted Salamander, *Ambystoma laterale*, in Southwestern Nova Scotia

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Brownlie, John. 1988. A disjunct population of the Blue-spotted Salamander, *Ambystoma laterale*, in southwestern Nova Scotia. *Canadian Field-Naturalist* 102(2): 263-264.

A total of 46 Blue-spotted Salamanders (*Ambystoma laterale*) observed in Kempt, Nova Scotia (44°26'N, 65°07'W), in April 1985 confirm the presence of this disjunct population.

Key Words: Blue-spotted Salamander, *Ambystoma laterale*, disjunct population, Kempt, Nova Scotia.

Bleakney (1951, 1952) reported Jefferson's Salamander, *Ambystoma jeffersonianum*, was common in several breeding ponds in Kempt area, Queens County, Nova Scotia, but voucher specimens were not preserved. Cook and Rick (1963) identified a salamander from Louisburg, Cape Breton County, as a Blue-spotted Salamander, *Ambystoma laterale*, and Gilhen (1974, 1984) examined a total of 295 blue-spotted *Ambystoma* from the northern mainland and Cape Breton Island and identified them as *A. laterale*. Several recent amphibian surveys in the Kempt area (W. F. Weller, personal communication; Gilhen 1974; L. Lowcock, personal communication) failed to rediscover blue-spotted salamanders in southern Nova Scotia. The road through Kempt in 1951 was narrow and gravelled and it was thought the roadside ponds in which Bleakney collected were destroyed when the road was widened and improved.

On the rainy night of 6 April 1985 I collected two Blue-spotted Salamanders crossing the highway towards a pond bordered by Speckled Alders (*Alnus rugosa*) and Red Maples (*Acer rubrum*) at Kempt, Queens County (44°26'N, 65°07'W). On the misty night of 15 April 1985 a total of 33 individuals were observed migrating to the Kempt pond, and 11 more individuals were observed

migrating there during a light rain the following night.

One of the salamanders collected on 6 April was preserved and deposited in the Nova Scotia Museum (Cat. No. NSM986-138-1(1)). Of the remaining 45 individuals observed, 39 were measured before release at the Kempt pond. On the 31 August 1985 two newly transformed juveniles were collected as they left the Kempt pond and were sent alive to Les Lowcock, University of Guelph, Guelph, Ontario. His electrophoretic analysis of blood samples identify them as *Ambystoma laterale* (Lowcock, personal communication).

The 39 Blue-spotted Salamanders ranged from 44 to 70 mm (mean 54.5) in snout to posterior angle of vent length and 83 to 122 mm (mean 99.3) in total length. The Kempt population falls well within the length ranges given by Gilhen (1984): 45 to 77 mm, snout to posterior angle of vent, and 78 to 140 mm in total length.

Gilhen (1974) points out that all the Blue-spotted Salamander localities in northern Nova Scotia are in areas underlain by sedimentary rocks. The Kempt locality is in an area of metamorphic slate.

Since April 1985 two additional breeding ponds, as evidenced by the presence of recently

transformed juveniles, have been found within 2 km of the initial discovery site.

Acknowledgments

I thank John Gilhen, Nova Scotia Museum, for his advice during the preparation of the manuscript.

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Reoccupation of Common Loon, *Gavia immer*, Territories Following Removal of the Resident Pair

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Croskery, Peter Ross. 1988. Reoccupation of Common Loon, *Gavia immer*, territories following removal of the resident pair. *Canadian Field-Naturalist* 102(2): 264–265.

Common Loons were removed from three small lakes in northwestern Ontario. Each lake was reoccupied within four days of removal and young were raised two years later on two of the three lakes.

Key Words: Common Loon, *Gavia immer*, Ontario, territory, breeding.

The existence, during the breeding season, of surplus non-breeding birds that will establish territories if the necessary resources become available has been reported for a variety of species (Tomba 1962; Watson 1967; Brown 1969; Stutchbury and Robertson 1985). Such a surplus has not been demonstrated for Common Loons, *Gavia immer*, although summer flocks of loons (Munro 1945; Rand 1948; Nero 1972, 1974; Reimchen and Douglas 1980) and single unmated, non-territorial loons have been reported (Olson and Marshall 1952; McIntyre 1975; Titus and VanDruff 1981).

To demonstrate that a surplus of non-territorial loons exist within an area, it is necessary to show that individuals exist in excess of available territories, and that vacated territories become occupied by different birds. I report an effort to examine the second condition.

Removal experiments were carried out near Ignace, Ontario, 49°25'N, 90°40'W, during the ice-free periods from 1982 to 1986. The study area

included 50 lakes within a land area of approximately 200 km². For each of the five years of the study, the number of occupied territories within the study area remained the same. Annual variation in total number of loons was a result of variation in the number of non-territorial birds, most of which were concentrated into flocks.

In all five years, the majority of loons arrived in the Ignace area during the second and third weeks of May, and by the first week of June territories were occupied and the summer resident population was established. In 1982 and 1983 three lakes; Highway 17E (11 ha), Little Butler (11 ha), Reguley (14 ha); were each occupied by one pair of loons and each was successful in fledging at least one chick. Occasionally a third adult was seen on Reguley Lake. During the second week of June 1984 the established pairs on each lake were collected. Nests with eggs were found on Highway 17E and Reguley Lakes. A nest without eggs was located on Little Butler.

Each lake was reoccupied by a pair of loons within four days of removing the original pair, and the new pair remained for the rest of that summer. All three lakes were occupied again in 1985 and 1986. In 1984 and 1985, no nests were found in spite of careful searches. Two of the lakes, Little Butler and Highway 17E, each had a nest with a single egg in 1986. Both eggs hatched and young were fledged. No nest was found on Reguley Lake in 1986, and occupancy of the lake by adult loons appeared irregular.

For Little Butler and Highway 17E lakes, the 1982, 1983, and 1984 nest sites were all in the same locations, within 0.5 m of the previous year's nest. The 1986 nest locations were very different, best described as across the lake from the previous nest location.

The origin of the new resident loons is unknown. However, this work demonstrates that searching is carried out by loons, since unoccupied breeding sites are quickly taken up after being vacated.

Since no evidence of nesting was found in either 1984 or 1985, I suggest that the new resident birds had not bred previously. This assumes that breeding birds would not relocate if successful elsewhere, or change location in the middle of a breeding season.

The absence of nesting may be the result of loons "assessing" habitat quality following occupancy and prior to attempting to raise young. This would explain why two lakes had delayed nesting, and why occupation of Reguley Lake was irregular in the third year following removal (i.e. habitat quality was assessed as poor).

Both pairs that nested were successful in fledging young. Clutches were small, one egg only, and both nesting attempts were initial clutches and not re-nest attempts. If these new occupants had not bred previously, these data provide insight on success rates for first-time breeding in Common Loons.

The new nest site locations on Little Butler and Highway 17E lakes suggest that the selection of a nest site may be unique to a particular pair. Furthermore, once a nest site is initially selected, that pair may have a preferential affinity for that site in subsequent years. This would explain the three years of nest site re-use noted prior to removal and explain the new nest locations found in 1986.

Acknowledgments

I wish to thank D. J. Penney, D. Kinsman, and B. A. Ward for their assistance in the field. P. Gray, J. P. Ryder, C. D. Fowle, and R. D. Scott reviewed early drafts of the manuscript. I thank A. J. Erskine and an anonymous reviewer for reading the manuscript and offering helpful suggestions.

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News and Comment

Editor's Report for Volume 101 (1987)

A total of 129 manuscripts (exclusive of news items and notices, Ottawa Field-Naturalists' club awards, and Annual Meeting Minutes, book reviews, and new title listings) were submitted to *The Canadian Field-Naturalist* in 1987. Because of the backlog of accepted manuscripts none of these were published in Volume 101. However, the steady increase in number of pages in recent volumes will facilitate the appearance of many in 1988, and the situation should markedly improve in 1989. Other approaches, such as narrowing our content, demanding even deeper reductions in text in individual submissions, or simply outright rejection of all papers for which the reviewers recommend extensive revision, are not considered viable options under present editorial policy nor in the best traditions of the journal. Similarly, cuts in News and Comment or Book Review sections would poorly serve the broad base of support on which the journal depends. Contributors, subscribers and members can best support this policy by recruiting additional subscribers or members.

Volume 101(1) was mailed 16 March 1987, (2) was delayed until 17 November 1987; and the last two issues were not mailed until the first half of 1988: (3) 27 April, (4) 16 July. On the more positive side, 101(2) was the largest single issue of the journal, 200 pages, and (3) was a close second at 188 pages. Volume 101 was the largest, 682 pages, of any produced in the journal's history. Realistically, we can hope to match publication to scheduled quarters by the end of 1988.

The number of research and special contributions for the volume are given in Table 1, the totals for Book Reviews and New Titles in Table 2, and the distribution of published pages in Table 3. Included in 101(2) were the third group of Status Reports for the Subcommittee on Fish and Marine Mammals of the Committee on the Status of Endangered Wildlife in Canada (COSEWIC). R.R. (Bob) Campbell made their publication possible not only through his coordination and editing but also by arranging payment of all page, figure and table costs, and the purchase of reprints, through the federal Department of Fisheries and Oceans.

Our publication of COSEWIC reports began in 1984 and appears to have been a substantial success by reaching naturalists and scientists the receive *The Canadian Field-Naturalist* and thus broadening the awareness and appreciation of the efforts of COSEWIC. Unfortunately, financial support has not been available to other subcommittees; although we have been able to include three plant status reports, their cost has had to be subsidized by the limited resources of the journal. We encourage individual authors to submit *and support* publication of their status data in *The*

TABLE 1. Number of research and observation manuscripts published in *The Canadian Field-Naturalist* Volume 101 (1987) by major field of study.*

Subject	Articles	Notes	Total
Mammals	22	19	41
Birds	12	18	30
Amphibians and Reptiles	0	4	4
Fish	2	3	5
Invertebrates	1	1	2
Plants	4	3	7
Paleontology	0	1	1
Total	41	49	90

*Excluded are review papers appearing in News and Comment: one note on original ground squirrel descriptions; 20 COSEWIC articles (one subcommittee report, 13 fish and 6 mammal status reports); the inventory of ecologically significant natural vegetation (Essex County), the list of original descriptions, 1932-1986; and two tributes.

TABLE 2. Number of book reviews and new titles published in the Book Review section of Volume 101 by topic.

	Reviews	New Titles
Zoology	36	181
Botany	12	67
Environment	14	116
Miscellaneous	9	28
Young Naturalists	—	61
Total	71	453

TABLE 3 Number of pages published in *The Canadian Field-Naturalist* Volume 101 (1987) by section (number of manuscripts in parenthesis).

Issue number	-1-	-2-	-3-	-4-	Total
Articles	85(12)	22 (4)	102(15)	62(10)	271(41)
Notes	29(13)	3 (2)	34(17)	36(17)	102(49)
News and Comment	1 (3)	5 (8)	2 (3)	10(19)	18(33)
COSEWIC	— —	145(20)	— —	— —	145(20)
Tributes	— —	4 (1)	4 (1)	— —	11 (2)
Other	— —	— —	14 (2)	9 (1)	23 (3)
OFNC Annual Meeting	— —	— —	9 (1)	— —	9 (1)
Book Reviews	14 (8)	21(19)	22(21)	25(23)	92(71)
Index	— —	— —	— —	19 (1)	19 (1)
Advice to Contributors	1 (1)	— —	1 (1)	1 (1)	3 (3)
Additional notices	— —	— —	— —	2 (2)	2 (2)
	130 —	200 —	188 —	164 —	682 —

Canadian Field-Naturalist in cooperation with the responsible subcommittee either as status reports in their original form or as papers which represent the information in a more concise format. The assessment of status of all animals and plants at risk in Canada is essential to promote the habitat protection needed to maintain at least representative populations. COSEWIC, a blending of judgement of federal, provincial and non-governmental agencies and acting on the advice of subcommittees of experts in each taxonomic group, has a very unique role in providing consensus recommendations that have wide acceptance. The original and complete status reports for all animals and plants considered to date are available at cost through the Canadian Nature Federation, 453 Sussex Drive, Ottawa, Ontario K1N 6Z4, acting on behalf of COSEWIC.

Other special features during the year included tributes to H. J. Scogan in 101(2): 161-164 and to G. P. Holland in 101(3): 470-473; "An inventory of ecologically significant natural vegetation in the province of Ontario I. Essex County" in 101(2): 474-486; and the "List of original descriptions published in *The Canadian Field-Naturalist*: 1932-1986" in 101(4): 627-635.

Elizabeth Morton provided, with characteristic energy, zest and judgement, major editorial assistance throughout the year for manuscripts at both the review and acceptance stages and also tackled routine acknowledgments and dispatch of manuscripts to reviewers. Louis L'Arrivée proof-read galleys and maintained the high quality he has established in this role.

George LaRoi continued as Coordinator for *The Biological Flora of Canada* series, E. Wilson Eedy as Book Review Editor, and W. J. (Bill)

Cody as Business Manager. The opportunity arose to pay special tribute to Bill in his 41st year in this capacity; the item appeared in 101(2): 159-160, achieving the intended complete surprise. Bill retired from the Agriculture Canada in December but will continue with them as a Research Associate and with us in his traditional role. W. Harvey Beck once again compiled the volume index and submitted virtually flawless final typescript gracefully under pressure.

A. J. Erskine (birds); C. G. Van Zyll de Jong and W. O. Pruitt, Jr. (mammals), C. Jonkel (predator-prey relations), D. E. McAllister (fish), S. M. Smith (insects), E. L. Bousfield (invertebrates), and C. D. Bird (plants) all played active roles as associate editors concerned with papers in their respective fields.

Their efforts were supplemented and aided by outside reviewers who have contributed largely anonymously to the critical evaluation of manuscripts that is vital to the journal's standards. The following are gratefully acknowledged for one or more individual reviews during 1987: M. G. Ainley, C. D. Ankney, C. A. Albright, G. W. Argus, J. C. Barlow, R. J. Bayer, M. Berrill, M. A. Bigg, J. S. Bleakney, R. Boonstra, H. Boyd, D. M. Britton, E. Brodo, D. F. Brunton, E. M. Bureson, S. W. Buskirk, R. R. Campbell, R. W. Campbell, P. M. Catling, B. W. Coad, W. J. Cody, A. Cooper, P. R. Croskery, E. J. Crossman, S. J. Darbyshire, N. David, R. W. Davies, T. Dick, D. W. Dunham, C. H. Ernst, W. N. Eschmeyer, J. B. Falls, R. Farmer, M. B. Fenton, J. K. B. Ford, A. J. Gaston, V. Geist, F. F. Gilbert, J. Gilhen, W. E. Godfrey, J. B. Gollop, D. C. Gordon, D. M. Green, P. K. Gregory, E. Haber, A. Harestad, V. L. Harms, L. V. Hills, M. Hoefs,

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M.O.M. Printing set and printed the journal, and Emil Holst and Eddie Finnigan and the staff once again provided the fine service and cooperation on which we depend. The National Museum of Natural Sciences continued to sanction my tenure as editor. R. E. Bedford and the Ottawa Field-Naturalists' Club Publications Committee, and Bill Gummer and the Club Council continued their support. Dan Brunton made many special efforts, including photographing Bill Cody in his natural habitat without revealing the purpose 101(2): 159; in 1987, not 1986 as given in the caption). Special thanks are due Thérèse Giroux for typing correspondence and Mike Rankin for a number of trips to the printer, both in times of overload. Above all in importance is acknowledgment of my continuing personal debt to Joyce.

FRANCIS R. COOK
Editor

Proceedings of the Urban Natural Areas Workshop, held at University of Calgary, 24 January 1987

The Federation of Alberta Naturalists is pleased to announce the publication of the proceedings for its *Urban Natural Areas Workshop*. These proceedings, published as Volume 17, Number 3 of the *Alberta Naturalist* includes 73 pages of articles and panel presentations relating to urban natural areas in Alberta, Canada, the United States and Great Britain. They should prove a useful reference source for anyone interested in promoting the establishment and use of urban natural areas. Contributors of the 15 articles and 16 photos included: wildlife biologists, naturalists, park interpreters, environmental educators, city and public lands planners, and an environmental lawyer.

The articles range from the philosophical "The birds, the bees and the bedroom community" by Gerry McKeating of the Canadian Wildlife Service; through the in-depth review "The development of urban wildlife programs in the

United States" by Daniel Leedy and Lowell Adams of the National Institute for Urban Wildlife; to the factual analysis of "Bird watchers of Point Pelee National Park, Canada" by Jim Butler and Greg Fenton of the University of Alberta. Case histories of urban natural area programs in Calgary, Medicine Hat and Red Deer, Alberta are contrasted with similar programs in Great Britain. From the panel discussion, the perspectives of professionals and amateurs are presented on the topic "How do we promote the establishment and use of natural areas in and around urban centres?", including some practical recommendations on planning, natural history interpretation, and the legal aspects of such areas.

Send Order and Remittance of \$8.00/Copy Postpaid (Cheque or Money Order in Canadian Funds) to:

FEDERATION OF ALBERTA NATURALISTS
Box 1472, Edmonton, Alberta T5J 2N5.

Alfred Bog

A major achievement in the preservation of wetlands was realized on 17 August 1988, with the purchase of 1500 hectares of land in Alfred Bog. Preservation of this wetland has been a high priority conservation objective of The Ottawa Field-Naturalists' Club for a number of years. This acquisition, together with some land purchased earlier, protects about a third of the Bog.

Alfred Bog is a 5000 hectare domed peat bog (4000 hectares of bog surrounded by 1000 hectares of peripheral wetland) located about halfway between Ottawa and Montreal. It is recognized as a wetland of provincial significance by the Ontario Ministry of Natural Resources and it is home to many rare species, the Southern Twayblade Orchid, *Listera australis*, Fletcher's Dragonfly, *Williamsona fletcheri*, the Bog Elphin Butterfly, *Incisalia lanoriaensis*, and the Spotted Turtle, *Clemmys guttata*, being examples.

The Club became actively concerned about the Bog in 1982, opposing an application to change the zoning of the 1500 hectare parcel mentioned above from "conservation" to "agriculture". We failed to prevent the zoning change but responded by teaming up with the Nature Conservancy of Canada to call a meeting of organizations interested in preserving the Bog. Attending the meeting on 26 October 1985, were representatives from 16 such organizations. The meeting appointed a committee,

chaired by a member of the OFNC Council, to pursue the preservation objective.

The committee is proud to announce this acquisition. The financing strategy calls for the purchase price of \$725 000 to be shared according to the following formula: 50% from Wildlife Habitat Canada, 25% from the Ontario Ministry of Natural Resources, and 25% privately (funding arranged by the Nature Conservancy of Canada). Under this arrangement, \$50 donated toward the purchase of land in Alfred Bog results, through matching grants, in a total of \$200 being made available.

The organizers have done their job. The challenge now passes to those of us who are concerned about the preservation of Alfred Bog to respond by providing the seed money. Please mail donations

TO: The OFNC Alfred Bog Fund
Box 3264, Postal Station C
Ottawa K1Y 4J5

OR: The Nature Conservancy of Canada
794A Broadview Ave.
Toronto M4K 2P7

Income tax receipts will be provided.

FRANK POPE
Chairman, Alfred Bog Committee,
Ottawa Field-Naturalists' Club

Status of the Green Sunfish, *Lepomis cyanellus*, in Canada*

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Meredith, G. N., and J. J. Houston. 1988. Status of the Green Sunfish, *Lepomis cyanellus*, in Canada. *Canadian Field-Naturalist* 102(2): 270–276.

Green Sunfish (*Lepomis cyanellus*) have a restricted range in Ontario. They have been found in the main watersheds and several small lakes of southwestern Ontario, and in the Quetico Park and Lake-of-the-Woods, Rainy River regions of western Ontario. The Ontario Ministry of Natural Resources and the Royal Ontario Museum have recently verified records of the species in eastern Ontario in the Rideau and Deslisle Rivers. The species is common within its range but generally not locally abundant at collection sites in southwestern Ontario. Green Sunfish are of no economic importance in Canada, and the southwestern Ontario habitat may be vulnerable because of the proximity to urban centres, industrialization and agriculture.

Le Crapet vert (*Lepomis cyanellus*) a une aire de répartition limitée en Ontario. On le trouve dans les principaux bassins versants et dans plusieurs petits lacs du sud-ouest de l'Ontario, ainsi que dans le parc Quético et les régions du Lac-des-bois et de Rainy River dans l'ouest de l'Ontario. Le Ministère des richesses naturelles de l'Ontario et le Royal Ontario Museum ont récemment vérifié les relevés de l'espèce dans l'est de la province, dans les rivières Rideau et Deslises. Même si l'espèce est commune dans son aire de répartition, elle n'est généralement pas abondante dans les sites de capture du sud-ouest de l'Ontario. Le Crapet vert n'a aucune importance économique au Canada et son habitat dans le sud-ouest de l'Ontario pourrait être vulnérable étant donné sa proximité des centres urbains, des industries et des exploitations agricoles.

Key Words: Green Sunfish, *Lepomis cyanellus*, Centrarchids, Ontario.

The Green Sunfish, *Lepomis cyanellus*, is a member of the Centrarchidae, the sunfish family. This family includes some of the more attractive and vividly coloured of the freshwater fishes of North America. Generally sunfishes are small, spiny-rayed, laterally-compressed fishes of the shallows in vegetated lakes, ponds and slow moving streams (Scott and Crossman 1973).

The Green Sunfish (Figure 1) has the typical, laterally-compressed sunfish body. These are small fish, generally not over 13 cm in length in Canada (Scott and Crossman 1973). The colour is brown to olive, being darker on the sides and dorsal surface. The sides usually display a series of 7 to 12 vague, dark vertical bars. The sides shade to lighter green vertically and the vertical surface is yellow to white. The opercular flap has a black centre, fringed in red or yellow. The breeding males may display deeper colour in the fins which may be edged in white, yellow or orange (Scott and Crossman 1973).

These are fish of east-central North America and the Canadian range is presently restricted to

Ontario. They are of little or no commercial importance but are taken occasionally by anglers.

Distribution

The Green Sunfish was originally restricted to eastern, central North America, but has been widely introduced elsewhere so that today the range covers much of the continental United States (Figure 2), with the exception of the northwestern and northeastern states (Lee 1980).

In Canada, the species has been recorded only from Ontario where it occurs in three disjunct areas (Figure 3). The species has been verified from several locations in, and outside, of the Quetico Park region of northwestern Ontario and in the Lake-of-the-Woods, Rainy River region (Figure 4). In southwestern Ontario, Green Sunfish occur in the St. Clair River drainage, particularly the Thames-Avon and Grand River systems and the Maitland, and Saugeen River system (Figure 4) of the Lake Huron Basin (Scott and Crossman 1973; Knott and Humphreys 1977; OMNR 1985). The species have also been recorded in several small

*Status reviewed by COSEWIC 7 April 1987 — species is not in jeopardy in Canada and not in any COSEWIC category.

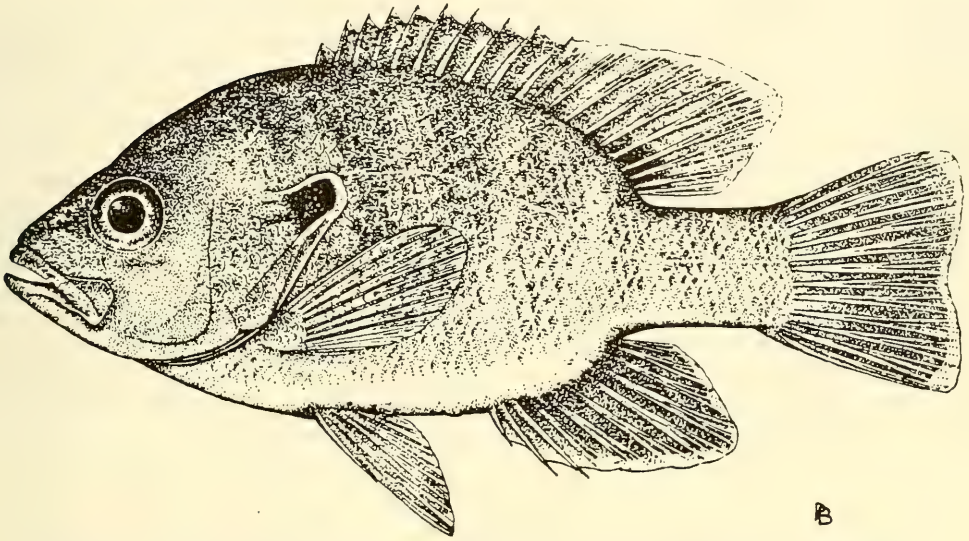


FIGURE 1. Green Sunfish, *Lepomis cyanellus*, [from Scott and Crossman (1973) by permission].

lakes and streams in Grey and Bruce Counties and Fanshawe Lake in Middlesex County (Scott 1967; Campbell and Reid 1970; Scott and Crossman 1973). Several records exist for the western Lake Ontario drainage in the Niagara, Burlington and Oakville areas (Figure 4, OMNR 1985).

The Ontario Ministry of Natural Resources (OMNR) and the Royal Ontario Museum (ROM) have also verified collections of Green Sunfish in eastern Ontario (Figure 4) from the Rideau and Delisles Rivers (OMNR 1985).

Protection

Green Sunfish are abundant in most areas where they occur within the United States and have greatly extended their range through introductions (Lee 1980). They have no special protection status in the U.S.

Although the Canadian population status is uncertain there have been no special protection measures for the species in Canada outside of the general protection offered by the habitat sections of the Fisheries Act.

Population Size and Trends

The Green Sunfish is widely distributed in the United States and relatively abundant in most areas of the range. The present distribution demonstrates the success of the species following introductions east of the Appalachians and west of the Rockies (Carlander 1977). Its abundance

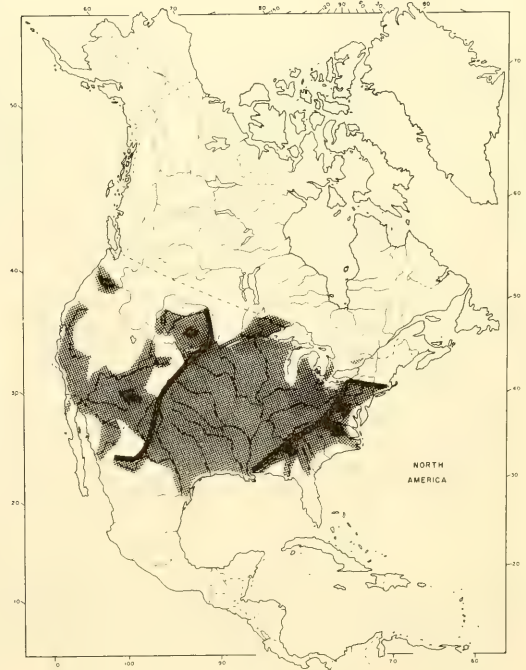


FIGURE 2. North American distribution of the Green Sunfish, *Lepomis cyanellus*, (modified from Lee 1980). 1. Range extension as a result of introductions.

appears to be negatively correlated with the abundance of other sunfishes, especially in areas where it has been introduced (Moyle and Nickols 1973).

There have been no population abundance studies for this species in Canada, and although it may be somewhat abundant locally in restricted areas, it is not well known (Scott and Crossman 1973). Crossman (1976) feels that the Green Sunfish is more commonly found in the Quetico area than elsewhere in Ontario, where they are found only in a small fraction of the lakes and streams of the province, particularly in the southwestern Ontario region.

Hubbs and Lagler (1970) indicated the species to be rare in Ontario as did Maher (1970) and

McAllister et al. (1985). Hallman (1959) found that Green Sunfish made up less than 5% of fish species collected in the Ontario streams in which they are known, and that often, the frequency was too small to be significant. Although the species is not well known in Ontario, it appears to be common in each of the three distinct areas of its range in the province, and recent updates and corrections to collections, especially by the cooperative efforts of OMNR and ROM (G. Goodchild, Ontario Ministry of Natural Resources, Toronto, Ontario, personal communication) have greatly increased the available knowledge on the distribution of this species in Ontario over that previously reported by Hubbs and Hagler (1970), Maher (1970) and Scott and Crossman (1973).



FIGURE 3. Canadian distribution of the Green Sunfish, *Lepomis cyanellus*.



FIGURE 4. Collection records of the Green Sunfish, *Lepomis cyanellus*, in Ontario: ○ University of Waterloo (13); △ National Museum of Natural Sciences (9); ■ ROM (30); ▲ OMNR (65).

It would appear that the species is not rare in Ontario and further additions to the records are expected as OMNR, ROM and the National Museum of Natural Sciences (NMNS) records are updated (G. Goodchild, personal communication). There is no indication of deliberate introductions in the province, although centrarchid fry could be inadvertently spread through transplantations of bass fry (A. E. Peden, British Columbia Provincial Museum, Victoria, British Columbia; personal communication) or by anglers releasing bait fish into new areas. It is unlikely that juvenile Green Sunfish would be utilized as bait fish as minnows are usually preferred and these fish are not common in most areas where minnows are taken for bait.

Records of Green Sunfish in eastern Ontario go back to at least 1958 for a collection at Brassile Creek at the mouth of the Rideau River (NMNS). OMNR recorded the species from the Delisle River (45° 17'N, 74° 45'W) in 1973 and these collections have since been verified by ROM (G. Goodchild,

personal communication). No other information is available for the species in eastern Ontario and the presence of this fish so far east of the known localities in southwestern Ontario is as yet unexplained. They may be here as a result of introductions but no knowledge of any deliberate introductions in the area exist. It is more likely that the species is resident to the area and has not previously been identified or collected. Further collections in the Ottawa and St. Lawrence River watersheds may confirm a wider distribution in the area.

Habitat

Green Sunfish are strictly freshwater fishes but, unlike other centrarchids, will tolerate alkalinities up to 2000 mg/L (Carlander 1977). They are often found in small intermittent streams and warm, muddy-bottomed, turbid pools with large amounts of vegetation. However, cleaner, larger, waterbodies, with a moderate flow may be preferred as growth seems to be greater in these areas than in

more turbid waters or smaller streams and ponds (Carlander 1977). In northwestern Ontario the species is found in habitats ranging from the shallows of moderately-sized lakes to small streams where it frequents dense growths of emergent vegetation (Crossman 1976).

The species is a colonial spawner in water of 40 cm or less in depth, and a water temperature of 20° to 28°C (Scott and Crossman 1973; Carlander 1977). The nests (redds) are constructed in sunlit waters with alkalinity from 400 to 960 mg/L on gravel or clay bottoms (Carlander 1977) in areas sheltered by rocks, logs, trunks or clumps of grass (Scott and Crossman 1973). Temperatures above 24°C may cause a cessation of spawning and repression of the gonads (Kaya 1973).

Green Sunfish show strong homing tendencies (Hasler and Wibly 1958; Kudman 1967) and are most active at dawn and dusk preferring to remain hidden in available cover unless feeding (Carlander 1977). They are often found in association with other centrarchids, particularly the Pumpkinseed (*Lepomis gibbosus*) and Longear Sunfish (*Lepomis megalotis*) with which they are known to hybridize (Carlander 1977). Hallman (1959) has described typical southwestern Ontario habitats and found the species to inhabit areas frequented by Rock Bass (*Ambloplites rupestris*) and the Smallmouth Bass (*Micropterus dolomieu*).

General Biology

There have been no Canadian studies on the biology of the Green Sunfish. In the United States, the species spawns from late spring to early summer. In Wisconsin, they spawn from mid-May to early August (Hunter 1963) and from June to August in Illinois, Maryland, Michigan and Iowa (Carlander 1977). Thus, they would probably be late spring to early summer spawners in Canada as well. Peak spawning activity occurs at 20° to 28°C, and the spawnings are multiple — every eight or nine days throughout the season (Hunter 1963). The males are highly territorial and build nests in colonies, in sunlit areas where the water is about 15 to 25 cm in depth (Carlander 1977). The courtship and parental care have been described by Hunter (1963).

Females have been reported to produce 15 000 to 50 000 eggs (Carlander 1977) which are yellowish, adhesive, and 1.9 to 1.4 mm in diameter. The male guards and fans the eggs which hatch in 3 to 5 days (Scott and Crossman 1973). The larvae are free swimming at 4.2 to 4.7 mm, within two days of hatching and average 23.7 mm by 57 days [Meyer 1970, see Auer (1982) for summary on

larvae and eggs]. Growth of the fry is rapid and young-of-the-year fish in Ohio were 20 to 64 mm by October (Trautman 1957) and weighed 1.3 to 25 g. There are no growth data for Green Sunfish in Canada, but the growth reported by Hubbs and Cooper (1935) for the species in Michigan may be representative. The fish increased in length by approximately 20 mm per year; no weight data were given but in Wisconsin increases in weight varied from 10 to 42 g/year with large increases in the fourth through the sixth years (see Carlander 1977). Maturity occurs at age 1 in more southern populations (Carlander 1977), but not until age 3 in Michigan (Hubbs and Cooper 1935). Males grow faster than females and appear to live longer (Carlander 1977).

Green Sunfish live from 7 to 9 years and may grow to a length of 203 mm in Ontario (Scott and Crossman 1973). In Ohio, they may grow to 274 mm and weigh 400 g (Trautman 1957). A Kansas specimen was recorded at 305 mm, weighing 964 g (Scott and Crossman 1973). In crowded conditions, the fish do not grow as well and stunting may occur (Carlander 1977).

The food of young Green Sunfish is zooplankton (Carlander 1977). The adults have a larger mouth than most other sunfishes and the diet consists of other small fishes and molluscs (Scott and Crossman 1973). They are usually found in association with Carp (*Cyprinus carpio*), where the species ranges overlap, particularly the Smallmouth Bass (Hallman 1959) and often fall prey to these species as well as preying on the young of these predators. The parasites of the species have been listed by Hoffman (1967).

Limiting Factors

The Green Sunfish is not common enough in Canada to be of economic importance, but they are susceptible to angling, and, although small, are good eating. In the United States they are treated as game fish in some areas, and if this practice were to be implemented in Ontario, populations might soon be depleted.

The species appears to be at the northern limits of its range in Ontario, and its association with Carp and Smallmouth Bass may restrict further range extensions through competition for habitat and food or by predation. Hallman (1959) reported that Green Sunfish comprised less than 5% of the frequency composition of species found in suitable habitat. Kott and Humphreys (1977) reported Green Sunfish from the Grand River system and suggested that the species had been able to enter the system through a drainage ditch (which

connected the Nith and Avon Rivers) which had been constructed to drain a low-lying area. Pumpkinseeds, Rock Bass, and Smallmouth Bass are also known from both systems. It is not known if the species has been successful in the Grand River system, but suitable habitat is available and the only limiting factors would be predation, competition for food and habitat, or interspecific hybridization.

Many of the streams in southwestern Ontario should provide suitable habitat for the species; however, these streams are in areas of large urban populations, industry or agriculture. Hallman (1959) has described the effects of cattle on these streams. Many streams in the area are intermittent at best, since drainage patterns have been influenced by agricultural and industrial activity.

Although the species seems to be tolerant of high turbidity (Carlander 1977), it is susceptible to heavy metals and nitrogen pollution, both common occurrences in the southwestern Ontario range. They also prefer a pH range of 6.0 to 9.6 with 4 to 8 ppm O₂, and the present problems of acid rain may have some influence on limiting populations in Ontario. However, the southwestern Ontario sites for the species are not susceptible to acid rain and the northwestern Ontario ones have not been effected yet.

Special Significance of the Species

Green Sunfish are of no economic value in Canada as they are too small to be an important sportfish although they will provide enjoyment with light tackle and are good eating (Crossman 1976). These fish are easily handled and make good laboratory animals and can survive in streams with fairly high summer temperatures [up to 36°C (Carlander 1977)]. They are at the northern edge of their range in Ontario, and as a relict species they are an important part of the evolutionary heritage of the country. The northwestern and southwestern Ontario populations probably had different biogeographic origins (see Crossman 1976) and may differ morphologically although this remains to be investigated.

Evaluation

The Green Sunfish is too small and uncommon to be of economic importance in Canada. Populations of species may be relict in Ontario, and deserve protection as an evolutionary heritage. They are found in only a few localities in a small part of southwestern Ontario and in two disjunct populations in northwestern Ontario and in eastern Ontario.

At present there do not appear to be any major threats to the species, although pollution, acid rain and habitat deterioration could be limiting in the future.

Acknowledgments

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Status of the Longear Sunfish, *Lepomis megalotis*, in Canada*

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The Longear Sunfish (*Lepomis megalotis*) occurs in Canada in three widely separated areas. Populations are known from southern Quebec, southwestern Ontario and the Rainy River, Lake-of-the-Woods area of northwestern Ontario, as well as Quetico Park. Population sizes are unknown, but the species is not abundant in any of the known areas with the exception of Quetico Park. Populations appear to be stable, but may be vulnerable to habitat alteration or disturbance, especially in southwestern Ontario. The species is at the northern edge of its range in Canada, and further range extensions are unlikely. The Longear Sunfish is common, though not abundant, in Canada but should be protected to prevent population declines from habitat loss or harvest for aquaria.

Au Canada, on trouve des Crapets à longues oreilles (*Lepomis mégalotis*) dans trois régions très distantes les unes des autres, soit le sud du Québec, le sud-ouest de l'Ontario et la région de Rainy River, Lac-des-bois dans l'ouest de l'Ontario, et le parc Quético. On ne connaît pas la taille des populations, mais l'espèce n'est abondante dans aucune des trois régions, sauf dans le parc Quético. Les populations semblent stables, mais peuvent être vulnérables face aux modifications ou aux perturbations de l'habitat, particulièrement dans le sud-ouest de l'Ontario. L'espèce se trouve à la limite septentrionale de son aire de répartition au Canada et il est peu probable qu'il y ait expansion. Le Crapet à longues oreilles est commun, mais peu abondant, au Canada; il devrait donc être protégé pour éviter les déclins de population résultant de la perte d'habitats ou de la capture aux fins de commerce des poissons d'aquarium.

Key Words: Longear Sunfish, *Lepomis megalotis*, Centrarchids.

The Longear Sunfish (*Lepomis megalotis*) is, as the name implies, a member of the Centrarchidae; those smaller, spiny-rayed fish with laterally compressed bodies which are some of the more coloured and attractive of our North American aquatic fauna. These are fishes of eastern North America but various species have been successfully introduced elsewhere (Scott and Crossman 1973).

Longear Sunfish (Figure 1) are smaller members of the family and usually quite short, not exceeding 76 to 152 mm in length or 60 g in weight. The fish have a deep body, being well compressed laterally. The opercular flap, which gives rise to the common name, is quite long, wide and turns up. It is black in colour, edged with red or yellow and useful in distinguishing the species from similar forms such as the Green Sunfish (*Lepomis cyanellus*). The body is usually highly coloured, the upper surface being olive green to rusty brown, the head and sides are mottled with orange and emerald to turquoise shading, the ventral surface is pale red, orange or yellow. A number (8 to 10) of vertical bars may be present and the cheeks are usually

orange with a series of uneven blue streaks radiating from the mouth to the eye. The fins are brown to orange with darker pigment at the base of the membranes (see Scott and Crossman 1973).

The species is not well known in Canada and was first recorded in southwestern Ontario in the 1920s (Hubbs and Brown 1929). Longear Sunfish are too small and not abundant enough to be economically important but its bright colour and still-water habitat lend a special appeal to these fish.

Distribution

Longear Sunfish are found in the sluggish waters of clear lakes, ponds and streams of east-central North America (Figure 2). It occurs west of the Appalachians from southern Quebec, south to the Gulf of Mexico in Alabama and western Florida. The species extends westward through Texas and tributaries of the Rio Grande in northeast Mexico and north through the eastern areas of the states from Oklahoma to central Minnesota through Wisconsin, Michigan, parts of western and southern Ontario and Quebec, and western New York (Scott and Crossman 1973; Bauer 1980).

*Status reviewed by COSEWIC 7 April 1987, the species is not in jeopardy in Canada or in any COSEWIC category.

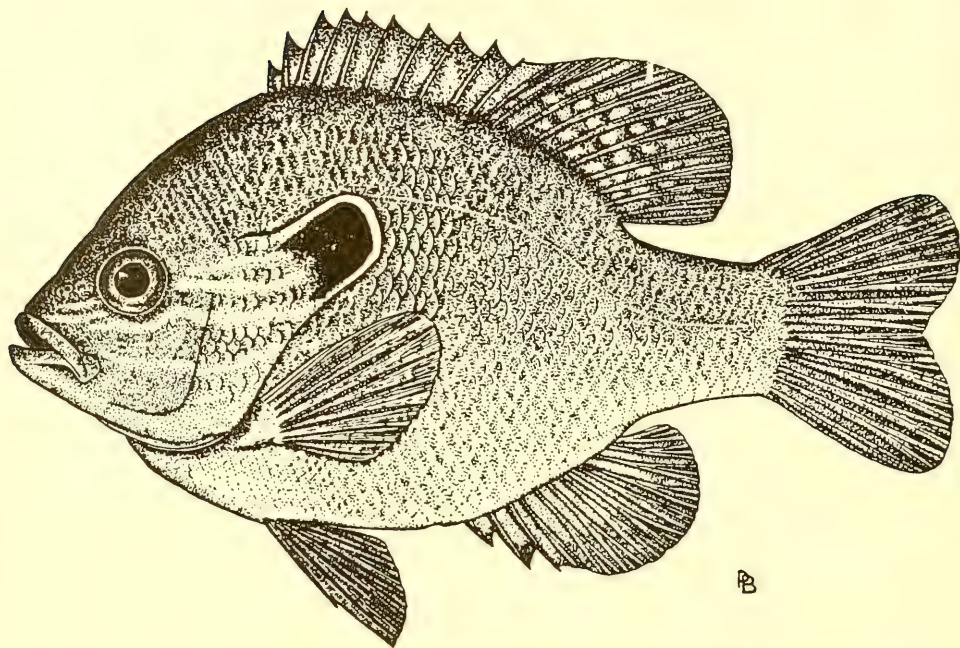


FIGURE 1. Drawing of the Longear Sunfish, *Lepomis megalotis*, [from Scott and Crossman (1973), by permission].

From four to six subspecies are recognized (Bauer 1980) but only two, *Lepomis megalotis megalotis* and *Lepomis megalotis peltastes*, have been adequately described. The subspeciation is currently under study by Bauer (see Bauer 1980) and others, but west of the Mississippi, it is almost impossible to denote forms and their distribution (Pflieger 1975). The Canadian populations are considered to be the northern form *Lepomis megalotis peltastes* (Gruchy and Scott 1966; Scott and Crossman 1973) as distinct from the central form *Lepomis megalotis megalotis*, which occupies the southeastern part of the distribution (Figure 2). Trautman (1957) indicated that the two forms intergrade along the Lake Erie-Ohio River divide.

In Canada, these fish are found in three, small, widely separated areas (Figure 3). The Longear Sunfish has been recorded from numerous localities in southwestern Ontario in the tributaries of Lake St. Clair, Lake Huron and Georgian Bay, north to near the French River (Scott 1967; Maher 1970; Scott and Crossman 1973). The species is also known from a few locations in the Rainy River, Lake-of-the-Woods area of western Ontario

(Gruchy and Scott 1966; Scott and Crossman 1973), in several locations in Quetico Park in the Hudson Bay watershed (Crossman 1976), and elsewhere in Northern Ontario from the Kenora, Fort Frances region (OMNR 1985). In Quebec, the species occurs in the upper St. Lawrence and Ottawa River systems (Scott and Crossman 1973; Mongeau et al. 1974).

Protection

The Longear Sunfish is common, though not locally abundant, throughout its range in the United States, and is afforded no special protection.

In Canada, no special protective measures are in place for this species other than the general protection of the habitat sections of the Fisheries Act.

Population Size and Trends

There have been no studies on the population size of the Longear Sunfish, and it is common, though nowhere locally abundant, in the United States (Bauer 1980). In Canada, it was formerly thought not to be abundant anywhere (Scott and

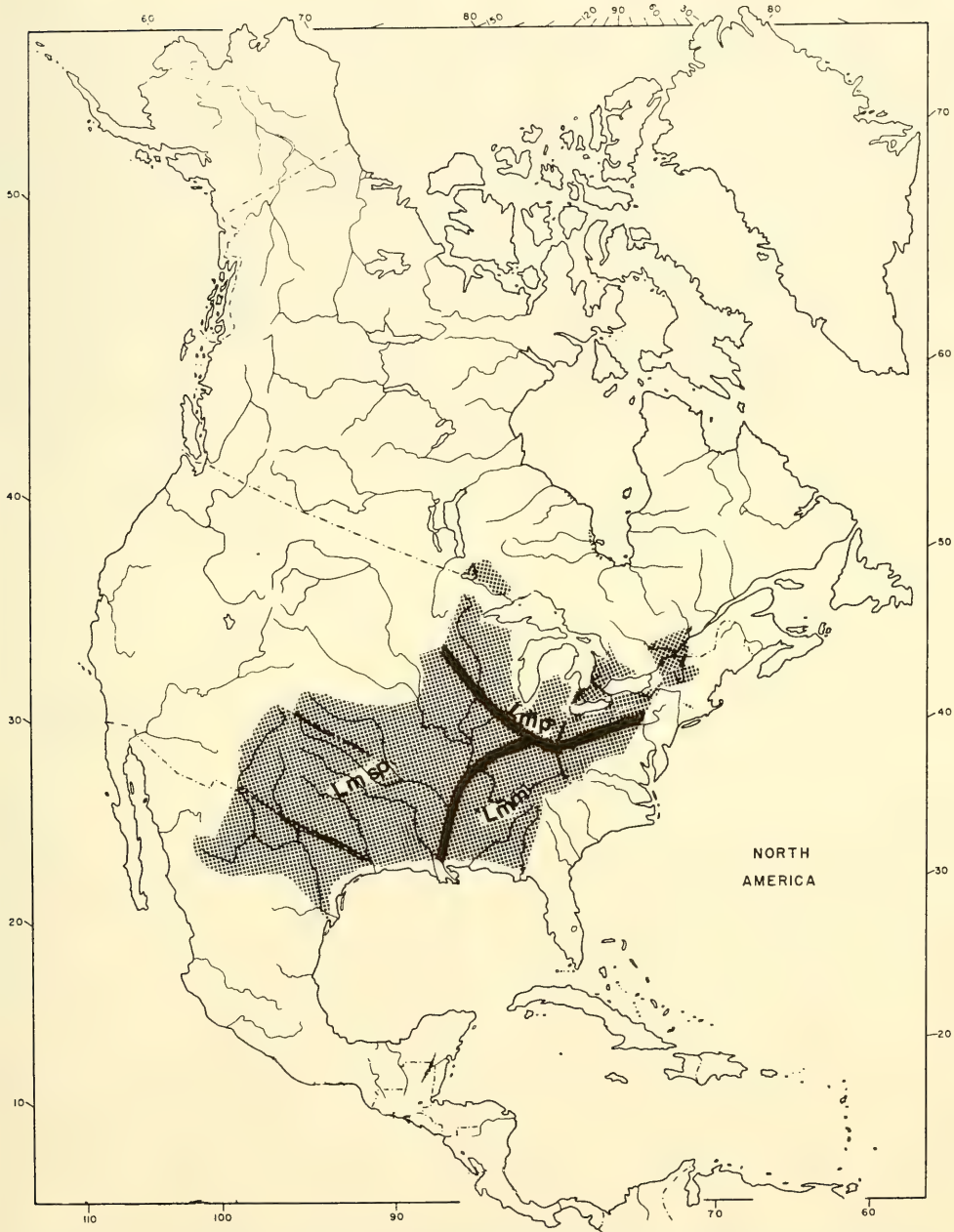


FIGURE 2. North American distribution of the Longear Sunfish (*Lepomis megalotis*). L mm = *Lepomis megalotis megalotis*; L mp = *Lepomis megalotis peltastes*; L msp = *Lepomis megalotis* subspecies undefined.

Crossman 1973) although common in some localities in the Thames watershed of southwestern Ontario. Maher (1970) listed the species under "rare or endangered" for Ontario and McAllister et al. (1985) indicated that it may be possibly "rare or endangered", but that considerable study would be required to determine overall status in regards to population sizes and trends.

The first Canadian records for the species were recorded by Hubbs and Brown (1929) in the tributaries of lakes Erie, St. Clair and Huron. It was unknown in Ontario, west of Lake Huron until discovered in the Rainy River — Lake of the Woods region in 1960 by Gruchy and Scott (1966). Gruchy and Scott (1966) felt that these populations were isolated from the Longear Sunfish populations in the Mississippi system in Minnesota at the end of the Pleistocene glacial period. The National

Museum of Natural Sciences last collected the species from the Rainy River region in 1979 (D. E. McAllister, National Museum of Natural Sciences, Ottawa, Ontario, personal communication). Crossman (1976) indicated that the species had been taken from nine locations between Quetico and Sturgeon Lakes, and that it may be more abundant in Quetico than in the previously known locations in Ontario and Quebec.

Previously, as indicated above, the species was considered to be not abundant in Canada and perhaps rare or endangered. However, recent efforts by the Royal Ontario Museum (ROM), National Museum of Natural Sciences (NMNS), and the Ontario Ministry of Natural Resources (OMNR) to update and correct collections have identified more than 150 collection sites for the species in Ontario since 1924 with more updates



FIGURE 3. Canadian distribution of the Longear Sunfish (*Lepomis megalotis*).

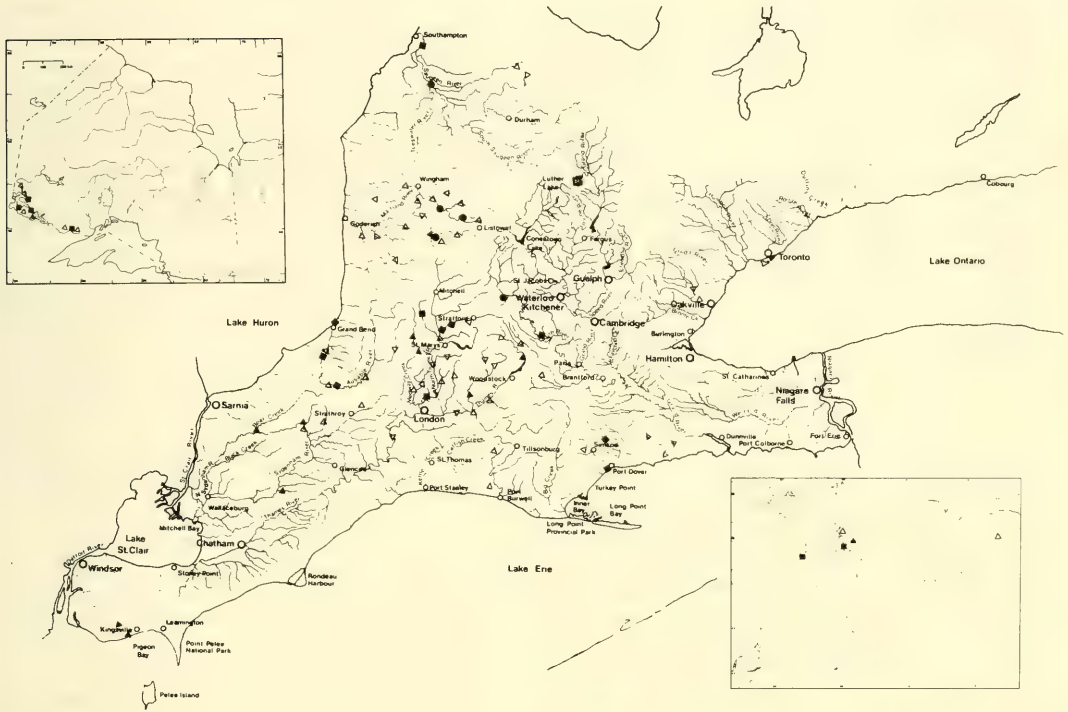


FIGURE 4. Collection records of *Lepomis megalotis* in Ontario: ● University of Waterloo; ■ ROM; ▲ NMC; △ OMNR.

pending (G. Goodchild, Ontario Ministry of Natural Resources, Toronto, Ontario; personal communication). OMNR records, current to 1981 (OMNR 1985) provide a number of new locations in northwestern Ontario outside of Quetico Park in the Lake of the Woods and Kenora, Fort Frances region (Figure 4), with new sites in southwestern Ontario as well. Although apparently widely distributed in northwestern Ontario and southwestern Ontario, it is not overly abundant at any one site where collected (D. E. McAllister, personal communication). It may be more abundant in its northwestern Ontario range than elsewhere in Ontario and Quebec (Crossman 1976).

In Quebec, Longear Sunfish have been found in the Upper St. Lawrence River drainage (Figure 5) as far east as Lake St. Pierre and Lake St. Paul (Mongeau et al. 1974). Quebec records (Québec Service d'Amenagement de la Faune 1985) also indicate the presence of the species in the Ottawa River drainage system at the northwest end of the Lake of Two Mountains and near Montebello.

Although not recorded on the Ontario side of the Ottawa River (Scott and Crossman 1973) the species should be looked for there. Mongeau and others (Mongeau et al. 1974; Mongeau and Massé 1976; Mongeau et al. 1979) indicate that the Longear Sunfish was not abundant at collection sites but was fairly widely distributed over the range.

There is no evidence that the fish have been introduced in northwestern Ontario (Gruchy and Scott 1966) or elsewhere in Ontario or Quebec (J. R. Mongeau, Québec Wildlife Management Service, Montréal, Québec; personal communication). The possibility of inadvertent introduction to new watersheds always exists, especially with smaller fishes that may be used as bait by sport fishermen. This practice is discouraged and controlled in Ontario and smaller, younger, representatives of the species are not commonly popular as bait. Deliberate introductions are tightly controlled in the Province, so that the recent increases in our knowledge of the extent of the range of the species in Ontario more probably

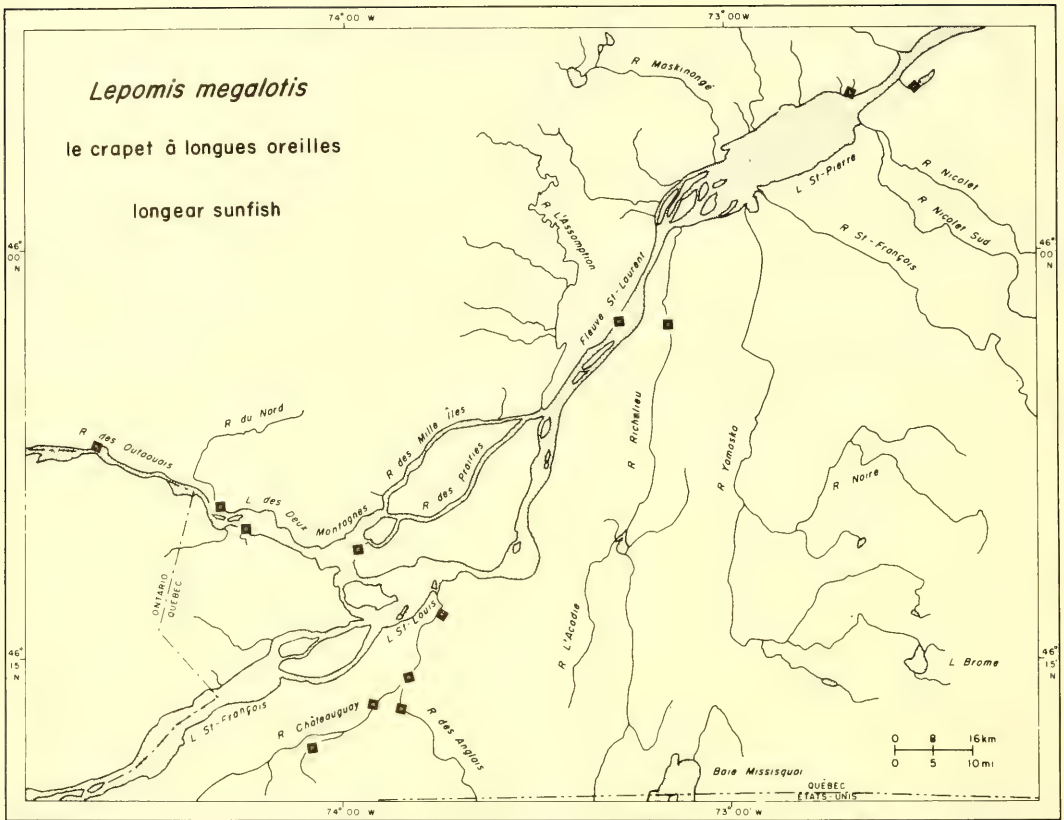


FIGURE 5. Collection records of the Longear Sunfish in Québec (after Mongeau et al. 1974): ■ Collection Sites.

represent just that, an increase in knowledge through updates or corrections to existing collections and through new collections, rather than extensions in the range. In the U.S. many introductions have been made and range extensions in many areas, particularly in the Western States, may be as a result of the stocking of reservoirs, etc. (Trautman 1957; Pflieger 1975; Bauer 1980). Although nowhere overly abundant in Canada, the species is common and no evidence of population decline exists.

Habitat

Longear Sunfish prefer moderately sized, shallow streams, ponds or small lakes, and they are usually found in shallow, moderately warm waters up to 37.8°C (Carlander 1977), and they become inactive at temperatures below 7°C. They seem to prefer clear water near areas of aquatic vegetation

(Scott and Crossman 1973). In the Thames River the Longear Sunfish are usually found over sand and gravel substrates where there is a slow to moderate flow of clear water (Keenleyside 1978). They appear to be intolerant to large amounts of silt and to high salinity (Carlander 1977).

Spawning takes place over nests built in gravel areas at water depths of 20 to 66 cm when water temperatures were 21.6°C to 22.8°C (Carlander 1977). Higher temperatures (Carlander 1977), or increased water flow, or depth as a result of flooding (Keenleyside 1978) may cause abandonment of spawning activity.

These fish tend to remain in home territories, and are not far ranging (Carlander 1977). They feed at the surface more than the other sunfishes (Scott and Crossman 1973), and do not often feed at night unless there is sufficient moonlight (Carlander 1977).

General Biology

Little is known of the biology of the species in Canada. Keenleyside (1978) has recorded spawning habits of Thames River fish and discussed the mechanisms of reproductive isolation between *Lepomis megalotis* and the Pumpkinseed (*Lepomis gibbosus*). Sexual maturity is probably attained at 2 to 4 years of age, and apparently males mature before the females (Scott and Crossman 1973). The species appears to be smaller in Canada than in the U.S., where the species is at the northern extension of its range (Scott and Crossman 1973). The reasons for this are unclear, but dwarfing appears to be a phenomenon in northern parts of the range (Scott and Crossman 1973) and northern fish in U.S. waters are smaller than their southern counterparts (Carlander 1977).

Spawning takes place in June or July in gravel over nests about 45.7 cm in diameter, and the male guards the eggs for the 5 to 7 days they take to hatch, and they may guard the young for a few days (Huck and Gunning 1967; Keenleyside 1978). The males are territorial and aggressive and will defend the nest against larger fishes (Carlander 1977).

The eggs average 1 mm in diameter and are adhesive, sticking to the gravel in the redd when deposited. Females 2 to 4 years of age may contain 2360 to 22 119 eggs (Scott and Crossman 1973), but Carlander (1977) has indicated that the total spawned ova may number 1417 to 4213. The eggs hatch within a week depending on water temperature (Carlander 1977). There are no data available on growth rates in Canadian waters, but Trautman (1957) found that young-of-the-year in Ohio were 20 to 46 mm in length by October. Hubbs and Cooper (1935) indicated that in Michigan these fish grow slowly and may increase 20 to 30 mm a year in the first 3 years, and put on an extra spurt of growth after reaching maturity at age 3 to 4 years when a maximum average length of 140 mm and an average weight of 51 g was reached. Trautman (1957) found the maximum length in Ohio to be 122 mm and a weight of 51 g. Growth in Canadian waters may be similar to that in Michigan as the largest Canadian specimen was about 150 mm (Scott and Crossman 1973) and maximum age is probably 8 years.

Aquatic insects and entomostracans are the major food of smaller fish. Fish eggs and terrestrial insects or mature aquatic insects are the primary food of the larger fish and small crayfish may also be important food items when available (Scott and Crossman 1973; Carlander 1977). Parasites for the species have been listed by Hoffman (1967).

These fish tend to remain in home territories, and are not far ranging (Carlander 1977), selecting spawning sites in shallow waters not far from their normal haunts (Keenleyside 1978).

Limiting Factors

The Longear Sunfish is too small and perhaps too scarce in Canada, to be of economic importance as a food fish. Its colourful and attractive appearance may, however, draw its attention to those who collect fish for the aquarium trade.

The species appears to be intolerant of silt and salinity (Carlander 1977) and prefers clear shallow waters near aquatic vegetation (Scott and Crossman 1973). Any habitat alteration or other activity that would increase siltation or change water levels could seriously limit present populations. This is a particularly important factor for southwestern Ontario populations which exist near high levels of industry and agricultural activity and near highways which are salted in winter. Trautman (1957) has documented the decline of the species in Ohio from streams where turbid conditions have increased, and its replacement by the Green Sunfish.

Recent attempts to remove dams on the Thames River to allow further upstream spawning movements of Walleye (*Stizostedion vitreum vitreum*) were curtailed when it was found such action could affect Longear Sunfish habitat and introduce new threats to the standing water communities above the dams (Ecologistics 1981).

These fish are usually found in the same habitats as other sunfishes such as the Bluegill (*Lepomis macrochirus*), the Green Sunfish and the Pumpkinseed with which they are known to hybridize (Scott and Crossman 1973; Carlander 1977; Keenleyside 1978). Repopulation of Longear Sunfish in streams decimated of fish has been found to be slower than for other species, especially if predators were present (Carlander 1977). Competition with other sunfishes for food and breeding areas may therefore, be limiting range extension in Canada as these fish are not far ranging and stay close to home territories (Carlander 1977). They are definitely not colonizers. Hybridization may also have some limiting effects. Although the Longear Sunfish are very aggressive during the breeding season they would be no match for larger predators such as Northern Pike (*Esox lucius*), Walleye or Smallmouth Bass (*Micropterus dolomieu*) which may share the same streams. Habitat preferences may be important in limiting further range extensions of the species.

Special Significance of the Species

The Longear Sunfish is too small and perhaps not abundant enough in Canada, to be of economic importance. These are colourful, attractive fish that do well in aquaria and are of interest to science in studies of fish behaviour and reproduction. The species is at the northern edge of its range and the widespread, isolated populations suggest that these fish have been isolated in these locations since the retreat of the last period of glaciation. Western populations probably had a different biogeographic origin than those in Southern Ontario and Quebec; thus, they are an important part of the evolutionary heritage of this country.

Evaluation

The Longear Sunfish is too small and perhaps not abundant enough to be of economic importance in Canada. However, the threats of habitat deterioration and alteration, and the possibility of collection for aquaria, could have deleterious effects on existing populations particularly in southwestern Ontario. These fish are found in three widely separated locations in Canada, one of which is a centre of heavy urbanization, industrialization and agricultural activity. Those frequenting the waters within Quetico Park are well protected but populations in southwestern Ontario and southern Quebec are vulnerable to habitat deterioration and contamination.

The species is at the northern edge of its range and further extensions in Canada are not likely, but the species should be looked for in Ontario, particularly in the Ottawa River watershed, as we may not yet know the full extent of the range in Ontario.

In consideration of these factors the position of the Longear Sunfish is at present stable in Canada, and the species should be considered healthy until evidence to the contrary is forthcoming.

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Status of the Green Sturgeon, *Acipenser medirostris*, in Canada*

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Houston, J. J. 1988. Status of the Green Sturgeon, *Acipenser medirostris*, in Canada. *Canadian Field-Naturalist* 102(2): 286-290.

The Green Sturgeon (*Acipenser medirostris*) is an anadromous Pacific sturgeon which is rare in Canadian waters. It occurs in North America in coastal waters from the Aleutian Islands and the Gulf of Alaska to Ensenada, Mexico and is known from Korea, Japan and the Bering Sea. Little is known of the life history, biology or habitat requirements of the species, but it is seldom found above brackish waters in large rivers such as the Fraser. It is thought that the life history may be similar to that of other sturgeons, and that they move into rivers in the fall and winter to spawn in the spring. The flesh and roe of the species has a disagreeable taste and odour and there is no commercial fishery. Green Sturgeon are, at times, taken incidentally as part of the salmon gillnet fishery. Given the protection of seasons and size limits, the limiting factors for the welfare of present populations would seem to be suitable spawning and feeding habitat. Dam construction on major rivers and other activities such as mining which alter the aquatic environment could be detrimental to this species and the White Sturgeon (*Acipenser transmontanus*) as well.

L'Esturgeon vert (*Acipenser medirostris*) est un poisson anadrome de la côte du Pacifique, qui est rare dans les eaux canadiennes. En Amérique du Nord, il fréquente les eaux côtières à partir des îles Aleutiennes et du golfe de l'Alaska jusqu'à Ensenada au Mexique. Il a aussi été signalé en Corée, au Japon et dans la mer de Béring. Peu de données sont disponibles sur le cycle vital, la biologie et les besoins de l'espèce en matière d'habitat, mais on sait qu'elle est rarement présente en amont des eaux saumâtres dans les grands cours d'eau comme le fleuve Fraser. On suppose que son cycle vital est semblable à celui d'autres esturgeons et que l'espèce pénètre dans les rivières en automne et en hiver pour frayer au printemps. Comme sa chair et ses oeufs ont une odeur et un goût désagréables, il n'existe aucune pêche commerciale de l'esturgeon vert mais celle-ci est souvent une prise accidentelle dans la pêche du saumon au filet maillant. Étant donnée la protection offerte par les saisons de pêche et les limites de taille, les facteurs limitatifs du bon état des populations existantes semblent être la disponibilité de frayères et de zones d'alimentation adéquates. La construction de barrages sur les principaux cours d'eau et d'autres activités comme l'exploitation de mines, qui modifient l'environnement aquatique, pourraient être néfastes à l'esturgeon vert ainsi qu'à l'esturgeon blanc (*Acipenser transmontanus*) dont l'aire de répartition marine est semblable.

Key Words: Green Sturgeon, *Acipenser medirostris*, sturgeons, rare fishes, North Pacific.

The sturgeons are large, heavy fishes with extended hard snouts; the mouth is vertical and sucker-like with four barbels. The body is covered by five rows of bony plates in place of scales. These are primitive fishes with the entire skeleton being composed of cartilage; the notochord is persistent and extends into the tail.

The Green Sturgeon (*Acipenser medirostris*) is a little known, rare species which is smaller than the other Pacific Sturgeon, the White Sturgeon (*Acipenser transmontanus*). These fish (Figure 1) are dark to olive-green in colour dorsally with the ventral surface being a lighter, paler shade of green.

Green Sturgeon are rarely found in fresh water but may move into the brackish estuaries of larger rivers and even into freshwater to spawn. Although generally smaller than the White Sturgeon,

they may reach lengths of up to 213 cm and weights of up to 136 kg. The usual weight in Canadian waters is 20 to 40 kg (see Scott and Crossman 1973).

Distribution

The Green Sturgeon is an anadromous Pacific species found from the Amur River in Siberia to northern Japan, Korea and the Bering Sea (McPhail and Lindsey 1970). In North America (Figure 2), the species has been recorded from Ensenada, Mexico (Moyle 1976) to the Aleutian Islands of Alaska (Morrow 1980) and is usually found near the mouths or estuaries of larger rivers (Hart 1973).

In Canada, little is known of the status of this fish, but there are authenticated records from the west coast of Vancouver Island, near Victoria

*Rare status approved and assigned by COSEWIC 7 April 1987.



FIGURE 1. Green Sturgeon, *Acipenser medirostris* [from Scott and Crossman (1973), by permission].

(Figure 3) and in the Fraser and Skeena rivers (Scott and Crossman 1973). There are unauthenticated reports of Green Sturgeon in northern British Columbia waters as well (E. Lane, Malaspina College, Nanaimo, British Columbia; personal communication). These fish are smaller and much less common than the White Sturgeon and rarely found above brackish water (Parks 1978).

Protection

Commercial fisheries exist for White Sturgeon in the tidal zone of the Columbia and Fraser rivers, but because Green Sturgeon are less abundant and smaller (158 kg maximum weight as compared to well over 454 kg for the White Sturgeon) and, the flesh is of inferior quality, they are harvested mainly as incidental species in gillnet fisheries for salmon (Parks 1978).

Season closures for other species and size restrictions are the only regulations that provide protection for these sturgeon populations. In Canada, any fish over 100 cm may be taken and in the U.S. in the Columbia River, a minimum size limit of 1.22 m protects younger fish, while a maximum size limit of 6 ft. (1.83 m) protects the female brood stocks. In non tidal waters of the Fraser River they may be taken only by angling; fish under 100 cm or over 200 cm may not be retained.

Population Size and Trends

Little is known of the status of this species and there is a definite requirement for population and distribution work on both Green and White Sturgeon. Some have been taken from time to time off the west coast of Vancouver Island (E. Lane, personal communication). Scott and Crossman (1973) and Hart (1973) indicate that it is not as abundant as the White Sturgeon.

Some idea of numbers may be gained from catch statistics. Green Sturgeon made up 5, 21 and 22% of total Columbia River sturgeon harvests in the periods 1941 to 1950, 1951 to 1960 and 1960 to

1971 respectively (Parks 1978). Using average annual landing statistics and average weights given by Parks (1978) this translates into roughly 200 to 500 fish per year for the period 1941 to 1950 and 1400 fish for the period 1951 to 1970. Semakula and Larkin (1968) indicated that the average spawning population of White Sturgeon in the Fraser River probably consisted of from 300 to 600 females. If Green Sturgeon are less abundant than the White Sturgeon, then spawning populations in Canadian waters must be indeed small. Moyle (1976) indicates that the species is much rarer than the White Sturgeon and in California, makes up less than 3% of sturgeon catch statistics.



FIGURE 2. North American range of the Green Sturgeon.

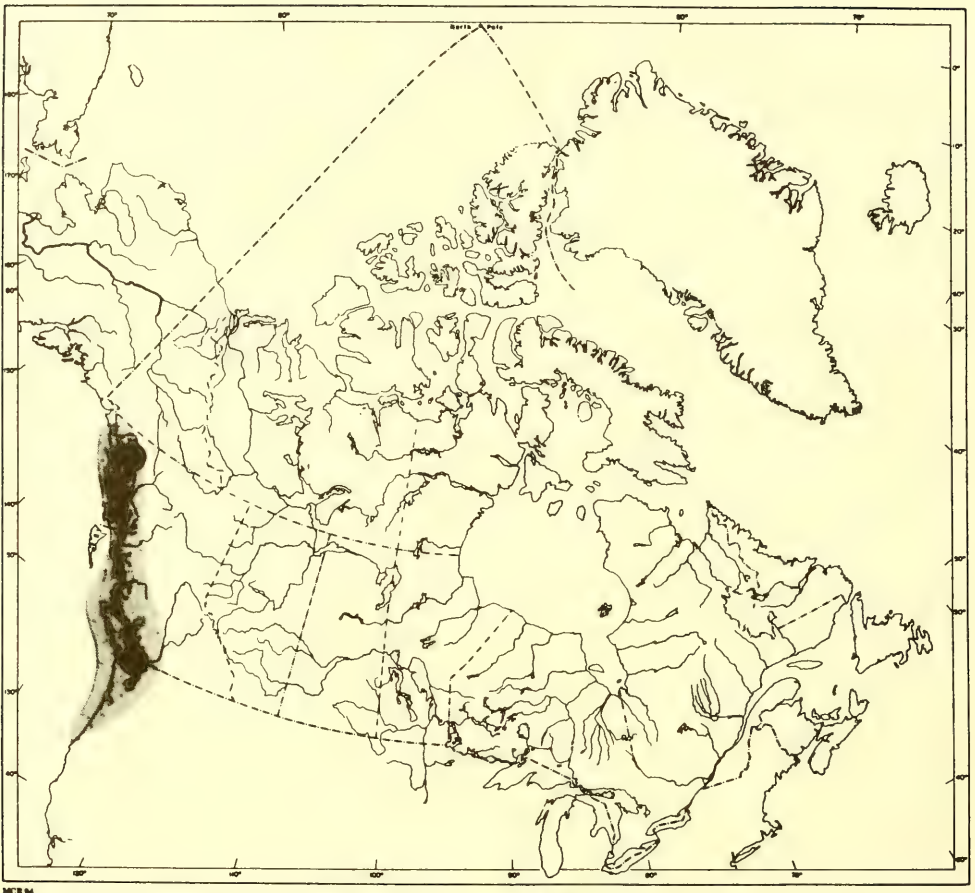


FIGURE 3. Canadian distribution of the Green Sturgeon: ● Authenticated records (*see text*); shaded area depicts the probable range.

There are no indications of population trends for the species; and, as mentioned previously, no good data exists on abundance or distribution. Increased catches of Green Sturgeon over the period 1940 to 1970, may reflect the imposition of maximum and minimum size restrictions which might mean the inclusion of more of the smaller species in catch statistics, but this is merely speculation. Green Sturgeon are mainly an incidental species in the salmon gillnet fishery and increased take of these fish in salt or brackish waters over the period indicated could also reflect increased effort in the salmon fishery. There is no evidence for a general population decline.

In 1985 and 1986 joint studies were conducted by Malaspina College and the British Columbia

Ministry of the Environment in the Fraser River between Albrion and Chilliwack (50 to 90 km from the Fraser River mouth). Approximately 900 sturgeon were tagged in 1985 and 500 in 1986. However, little attention was paid to species identification in 1985 (it was assumed that all were White Sturgeon) but care was taken in 1986. Of the 500 tagged in 1986 only two appeared "different" but were not positively identified as Green Sturgeon (W. T. Munro, Wildlife Branch, British Columbia Ministry of the Environment, personal communication). Recent information suggests that the sturgeon of the Skeena River are Green Sturgeon. A few are taken each year near the mouth of the salmon gillnet fishery. (W. T. Munro, personal communication).

Habitat

There is little, if any, literature available on the life history or habitat requirements of these sturgeon. Apparently these fish rarely occupy freshwater, except to spawn. However, they are often found in the salt or brackish waters near the mouths of large rivers along the coast (Scott and Crossman 1973; Parks 1978). It is at times taken as an incidental species in the salmon gillnet fisheries in the Columbia and Fraser rivers and may move into freshwater during the fall and winter to spawn in the spring (Scott and Crossman 1973).

The life history and habitat requirements are thought to be similar to those of the White Sturgeon (Scott and Crossman 1973; Morrow 1980). White Sturgeon are thought to stay close to shore in shallow marine waters and seasonal movements are related to water temperature (Haynes and Gray 1981). They have been taken in water of temperatures ranging from 0°C to 23°C (Scott and Crossman 1973). Spawning may take place over rocky bottoms in swift waters, near rapids or waterfalls, when temperatures are from 8.9° to 16.7°C, as has been reported for the White Sturgeon (Scott and Crossman 1973). Diel movements are probably related to temperature and food requirements (Haynes and Gray 1981).

The Green Sturgeon, like other sturgeon, is a bottom feeder, the food consisting predominantly of chironomids, mysids, *Daphnia*, *Chaobus* larvae, molluscs, copepods and other invertebrates. Large fish may also take fish and crayfish which have been sucked up off the bottom or taken alive (Scott and Crossman 1973). There may be some competition with the White Sturgeon for food and suitable habitat, however, Green Sturgeon are seldom far from salt water — White Sturgeon are often found far inland and may spawn at sea. Deterioration in water quality from mining activities has been shown to affect sturgeon movements and reproduction probably through impact on the food supply (Graham 1981).

General Biology

No information exists on the biology of this species. Since it is usually seen in rivers in the fall as an incidental catch of the salmon fishery, it has been assumed that it may move into freshwater during the fall and winter to spawn in the spring (Scott and Crossman 1973). The life history may be similar to that of the White Sturgeon which spawns during the spring in water temperatures of 8 to 16°C (Scott and Crossman 1973; Moyle 1976; Wydoski and Whitney 1979).

Sturgeon in general are long-lived, slow growing fish that mature slowly. Growth rate may only be 51 to 76 mm a year or less (Greeley 1937; Magnin 1963a: Shortnose Sturgeon (*Acipenser brevirostrum*); Harkness and Dymond 1961; Lake Sturgeon (*Acipenser fulvescens*); Magnin 1963b: Atlantic Sturgeon (*Acipenser oxyrinchus*); Semakula 1963; Semakula and Larkin 1968: White Sturgeon) until well past maturity and ages for some sturgeons may exceed 100 years (Mackay 1963). Growth rate in length decreases after sexual maturity and increases thereafter are mainly in weight. Age of maturity varies with species and location, but may be in the order of 11 to 22 years for males and 14 to 34 years for females (Rousso 1957: Lake Sturgeon; Magnin 1963 a,b: Shortnose and Atlantic Sturgeon; Semakula 1963; Semakula and Larkin 1968: White Sturgeon). This literature also indicates that the females spawn more than once after first spawning, but only after increasing intervals of years. In younger females, the interval may be 4 years and 9 to 11 years in older females. The largest Green Sturgeon reported was 2.3 m in length and weighed 158 kg however, they seldom exceed 1.3 m and 45 kg and most of those caught weigh between 20 to 40 kg (Moyle 1976; Wydoski and Whitney 1979).

As indicated previously, little is known of the movements of Green Sturgeon, but they are seldom found upstream of brackish water (Parks 1978). It is assumed that they move into the lower reaches of the rivers in the fall and winter to spawn in the spring (Scott and Crossman 1973). Spawning requirements may be similar to those of the White Sturgeon and movements may be dictated by water temperatures. Tagging studies carried out in California indicated that Green Sturgeon do move great distances. Fish tagged in San Pablo Bay, California, have been recovered along the Oregon and Washington coasts (Wydoski and Whitney 1979).

Nothing is known of the behaviour or adaptability of these fish although the White Sturgeon which has an overlapping distribution has been found to be sensitive to habitat perturbations caused by mining activities (Graham 1981). Semakula and Larkin (1968) have also shown that the sturgeon fishery of British Columbia exhibits the properties [as described by Ricker (1963)] of fish stocks with great longevity that respond to exploitation with drastic population declines and slow recovery.

Limiting Factors

The main limiting factors for Green Sturgeon may be the availability of large rivers with suitable estuaries. Estuarine pollution may be detrimental

as may alterations in habitat through mining or other industrial activities. Such effects may be indirect because of their more direct effects on the forage base.

Commercial exploitation could seriously deplete existing populations, but the flesh and roe of this species is inferior to that of other sturgeon, and is not likely to be utilized commercially. As it is taken only incidentally in the salmon fishery, and the older fish are probably unexploited, this does not seem to be a serious factor at present. Sturgeon catches have been relatively stable over the past few years (Parks 1978) and current regulations of size limits and closed seasons for other species may be successful in maintaining the populations. The sturgeon sports fishery in the Fraser River may account for small numbers of fish each year but the numbers of this species taken are apparently not significant.

Special Significance of the Species

The Green Sturgeon is not utilized commercially in Canada, as the flesh and roe have a disagreeable taste and odour. A small commercial enterprise has apparently existed in the Bering Sea (Magnin 1959), but this would not affect Canadian stocks.

Evaluation

It would appear that Green Sturgeon are not common in Canadian waters even though they may appear in numbers in some years off Vancouver Island. What little is known of the population would suggest that adult populations are in the low thousands and they certainly may not be as abundant as the Shortnose Sturgeon of New Brunswick which COSEWIC has categorized as rare.

Since the flesh is not desirable commercially, they are not threatened directly by the sturgeon fishery, but are taken incidentally as a by-catch of the salmon fishery. There is no indication that populations are declining, but more protection could be afforded through more restrictive seasons and size limits. The species should be considered as rare until evidence of population size and trends is forthcoming.

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Status of the Paddlefish, *Polyodon spathula*, in Canada*

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The Paddlefish, *Polyodon spathula*, is widely distributed in the Mississippi River drainage. It was reported in Canada from a few specimens collected in the Great Lakes region around the turn of the century. No paddlefish have been recorded in Canada during the last 70 years.

Le spatulaire, *Polyodon spathula*, se trouve largement répandu dans le bassin du fleuve Mississippi. Il est représenté au Canada par quelques rares spécimens recueillis dans la région des Grands Lacs vers le début du siècle. Depuis 70 ans, on n'a signalé aucun spatulaire au Canada.

Key Words: Paddlefish, *Polyodon spathula*, extirpated fishes, Mississippi drainage, polyodontids

The Paddlefish (*Polyodon spathula*) represents one of the most primitive groups of fish. At the turn of the century, their northern range included parts of the Great Lakes; however the species is now considered extirpated in Canada. The species is extant in the United States in the Mississippi River drainage.

The Paddlefish (Figure 1) is distinguished by having a long paddle-shaped snout. It is a robust, smooth-skinned fish, growing rapidly to an average length of 150 cm and weighing approximately 67 kg at maturity. Its skin is dark blue-grey to black with a light underside. It is caught commercially for caviar as well as for its flesh and is also taken by sport fishermen in the United States.

Distribution

The present range of the Paddlefish (Figure 2) includes the Mississippi River system from Montana to Louisiana as well as several smaller drainages which empty directly into the Gulf of Mexico (Burr 1980). This species was reported from the Great Lakes around the turn of the century (Halkett 1913; Trautman 1957).

The occurrence of this species in Canadian waters (Figure 2) is based on reports of single specimens collected in Lake Huron, near Sarnia, in the Spanish River, Georgian Bay, and in Lake Helen on the Nipigon River (Halkett 1913). Authentication of Halkett's records has proven difficult and has lead some authorities to question the validity of Canadian records (E. J. Crossman,

Royal Ontario Museum, Toronto, Ontario; personal communication). Trautman's (1957) records are derived from the U.S. waters of Lake Erie.

Since the turn of the century the peripheral range of the Paddlefish has shrunk and the relict population of the Great Lakes has been lost (Eddy and Underhill 1974).

Protection

No specific legal protection exists for this species in Canada.

The Paddlefish is listed on several state endangered species lists such as Wisconsin, Texas, North Carolina, and Minnesota. The species is also protected in other states by harvest quotas, commercial harvest size limits, and tag registrations (Combs 1982). Carlson and Bonislawsky (1981) conducted a survey of management strategies in the mid-western states and concluded that protective classifications should apply only to specific states or to a relatively small region.

Population Size and Trends

Several authors (Hubbs and Lagler 1947; Eddy and Underhill 1974; Burr 1980) suggest that the Paddlefish has been extirpated from the Great Lakes. Elsewhere, populations remain extant; in some instances the Paddlefish appears to be reinvading previously lost range (Gengerke 1983).

Swain et al. (1980) suggest the possibility of introduction of this species into the Souris and

*Extirpated status approved and assigned by COSEWIC 7 April 1987.

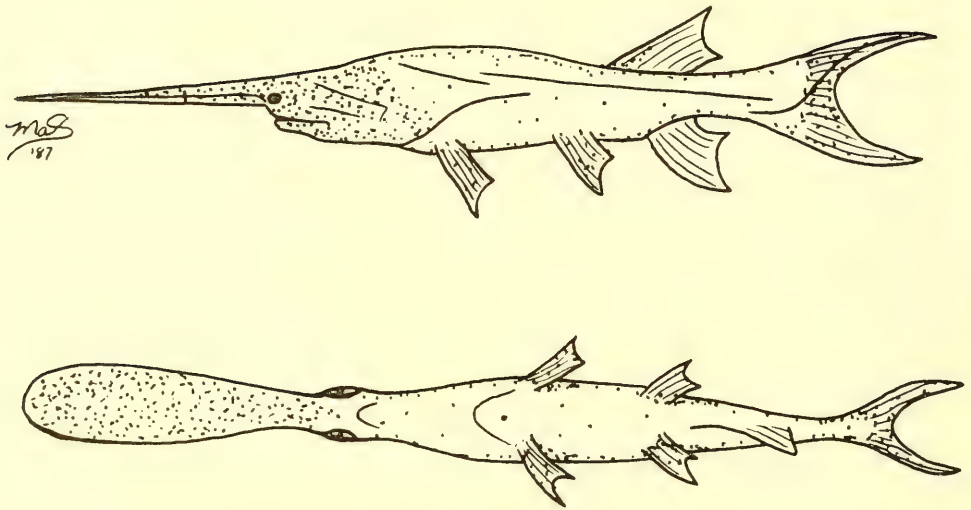


FIGURE 1. Drawing of the Paddlefish, *Polyodon spathula*, lateral and ventral views. (Drawing by M. Service, courtesy Department of Fisheries and Oceans.)

Red River systems in Manitoba through the Missouri River system via the Garrison Diversion Project. Carlson and Bonislowsky (1981) confirmed the presence of a Paddlefish population in Lake Sakakawea, North Dakota, this population may expand into Manitoba once the Garrison Diversion Project is completed.

Commercial harvest of specific populations is permitted in twelve mid-western and southern states. In general, commercial harvest of Paddlefish in the Mississippi Valley is small compared to catches around the turn of the century (Carlson and Bonislowsky 1981). The largest Paddlefish fisheries presently exist in the Tennessee, Mississippi, Cumberland, Arkansas, Yellowstone and Osage rivers (Gengerke 1983).

Habitat

Paddlefish specimens collected from Canada at the turn of the century were taken from inshore areas of the Great Lakes or from moderately large tributary rivers of the Great Lakes (Halkett 1913).

Paddlefish are reported from large slow-moving waters of the Mississippi River system (Pflieger 1975; Rosen and Hales 1983). Southall and Hubert (1984) reported that habitats preferred by Paddlefish are seasonally variable, and are directly linked to food supply (they are invertebrate filter feeders) and flow rates. During the spring spawning period Paddlefish were found to congregate below dams and in tailwater areas.

Paddlefish utilized main channel borders, backwater areas and areas of reduced current. Russell (1983) reported that populations had developed in some large man-made impoundments, but Paddlefish must have access to large, free-flowing rivers to spawn. He suggested that their spawning needs include a water temperature near 60° F (16° C), clean gravel substrate for egg attachment, and increased water flow to trigger spawning. Because of these exacting requirements a precise timing of events is necessary to stimulate migration and ensure successful reproduction.

Trends in habitat quality in the Great Lakes are unknown. Many of the structures which may have blocked upstream migration around the turn of the century are still present or have been replaced by other structures which also block migration.

Rate of habitat change is unknown. Site specific modification to migratory routes may benefit United States populations, but would not impact the status of this species in Canada.

In the U.S., barriers to migration and loss of suitable spawning habitat have been identified as causes of range fragmentation.

Biology

Reproductive Capability: No information on the reproductive capability of Paddlefish taken from the Great Lakes is available. The only life history data available for Great Lakes Paddlefish are provided by Trautman (1957) who suggests that Lake Erie specimens were of adult size.



FIGURE 2. Distribution of the Paddlefish in North America.

- Present U.S. distribution
- Former Canadian distribution

The following information is derived from Paddlefish populations extant in the Mississippi River system. Paddlefish grow rapidly with a maximum size of approximately 2.2 m total length (TL). Mean total lengths for adults from several mid-western populations range from 70 to 150 cm (Carlander 1969). Growth rates between populations are extremely variable (Bonislawsky 1977; Pasch et al. 1980; Combs 1982).

The maximum life span of Paddlefish is reported at approximately 30 years. Carlson and Bonislawsky (1981) report that in Missouri, maturity is attained at lengths of about 140 cm TL for females and 127 cm TL for males; and that females first reach maturity at between 7 and 14 years. Russell (1983) states that males generally reach sexual maturity at about 7 years old, females at 10–12 years. Carlson and Bonislawsky (1981) report that

Meyer (1960) and Sprague (1961) suggest that most female Paddlefish probably spawn at intervals of 2–7 years. Few estimates of fecundity have been made, despite the relative importance of this species as a source of caviar. Meyer (1960) reported that two adult females each contained approximately 140 000 eggs. Artificial propagation methods have been developed (Hicks 1983).

Recruitment of Paddlefish to the Canadian population apparently fell below the mortality rate near the end of the last century. In U.S. populations recruitment is variable, a number of populations are self-sustaining, but others are enhanced through hatchery stocking (Graham 1983).

Species Movement: Several studies have suggested that paddlefish are very mobile, especially during spring spawning migrations (Russell et al. 1980; Van Eeckhout 1980; Southall and Hubert 1984). Unkenholz (1983) reported that one tagged Paddlefish moved 1240 miles (1 995 km) down the Missouri River and into the Mississippi River. Long range movements of that kind throughout the Paddlefish native range have been impacted by various water developments.

Paddlefish move from over-wintering areas, often from reservoirs or lake-like expanses of large rivers, to spawning areas during the spring. Combs (1982) suggests that Paddlefish are vulnerable to harvest during spring spawning migrations.

Behaviour/Adaptability: Paddlefish populations have been negatively impacted by anthropogenic changes to their habitat; however, recent studies by Southall and Hubert (1984) suggest some degree of adaptation. These authors reported that Paddlefish could move through open dam gates, depending on operating regimes, and that Paddlefish select many other man-made features such as rock piles, revetments, and locks as holding areas. Paddlefish have been successfully cultured and hatchery stocks now support several Paddlefish populations.

Limiting Factors

The primary factors responsible for changes in distribution and abundance are: (1) destruction of spawning grounds; (2) blockage of movements by dams; (3) channelization and elimination of backwater areas; (4) dewatering of streams; (5) industrial pollution and; (6) over-harvest (Carlson and Bonislowsky 1981).

Alexander and Pasch (1983) state that Paddlefish stocks, even the most abundant, are susceptible to commercial over-harvest because

individuals mature slowly and are easily caught. They also state that, although no Paddlefish populations have been extirpated solely by commercial overharvest, management to prevent severe depletion would allow sustained economic yield and ensure continued existence of exploited populations.

No efforts have been made to re-establish Paddlefish in the Great Lakes.

Special Significance of the Species

No specific public or scientific interest has been identified for this species in Canada.

In areas where Paddlefish are extant this species is recognized as a sport and commercial species, primarily for caviar (Alexander and Pasch 1983; Gengerke 1983), significant public and scientific interest has been generated. The Paddlefish also represents one of the most primitive groups of fish in North America, and is therefore of interest to the scientific community for genetic and evolutionary studies.

Evaluation

The following factors were used in the evaluation of the status of Paddlefish in Canada:

1. This species is represented in Canada by very few specimens collected in the late 1800s and early 1900s.
2. The population in Canada is recognized as a relict population located at the northern edge of its range.
3. Paddlefish populations are much reduced in parts of the former range as a result of the actions of man.
4. Paddlefish remain common in many parts of the range in the Mississippi River system.

Based on the information evaluated, it is recommended that this species be classified as extirpated from Canada.

Acknowledgments

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Status of the Pacific Sardine, *Sardinops sagax*, in Canada*

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The Pacific Sardine (*Sardinops sagax*) seems to have been primarily a transient visitor to Canadian waters during the early portion of this century. The available evidence favours the thesis that sardines migrated progressively further north as they aged during their annual trek from spawning to feeding areas. However, there is also a body of evidence consistent with the notion of a genetically discrete stock of fish that spawned at the northern extremity of the species range and subsequently migrated into British Columbia waters. The demise of all but the most southerly portions of the historical stocks through a combination of overharvesting, adverse environmental conditions, and possible interspecific competition with the Northern Anchovy (*Engraulis mordax*) preclude the resolution of these hypotheses at present. Indications of rebuilding of the northern sardine stock in the California area may auger well for a return of sardines to British Columbia waters either through a return of northern migrants as earlier this century, or through the recolonization of a niche vacated by a now rare far northern sardine subpopulation.

La Sardine du Pacifique (*Sardinops sagax*) semble avoir été surtout une visiteuse de passage dans les eaux canadiennes durant la première partie du siècle. Les indications disponibles appuient l'hypothèse voulant que les sardines aient migré progressivement plus au nord à mesure qu'elles vieillissaient au cours de leur migration annuelle des aires de fraie vers les aires d'alimentation. Cependant, il y a également un ensemble de preuves compatibles avec la notion d'un stock de poisson distinct sur le plan génétique qui frayait à l'extrémité nord de l'aire de dispersion de l'espèce et qui a migré ultérieurement dans les eaux de la Colombie-Britannique. La disparition de tous les stocks antérieurs sauf des parties les plus méridionales de ces derniers suite à la surexploitation, à des conditions environnementales défavorables et à la concurrence interspécifique possible avec l'Anchois du nord (*Engraulis mordax*) empêche de confirmer ces hypothèses pour le moment. Des indications d'une reconstitution du stock de sardine du nord dans la région de la Californie peuvent très bien présager un retour des sardines dans les eaux de la Colombie-Britannique soit par un retour de migrateurs vers le nord comme au début du siècle ou par la recolonisation d'une niche laissée vacante par une sous-population de sardines maintenant rare située loin au nord.

Key Words: Pacific Sardine, *Sardinops sagax*, rare and endangered fishes, pilchards.

The Pacific Sardine (*Sardinops sagax*) is a schooling pelagic species that dominated the fisheries along the west coast of North America earlier this century when vast quantities were taken for food or were reduced to oil. It is a very active fish and avoids nets readily; it is taken successfully only at night when the moon is not bright. It is similar in size and appearance to the Pacific Herring (*Clupea harengus pallasii*) with which it was coincident in the Pacific Northwest. This sardine (Figure 1) may be distinguished by fine striae on the operculum, and specialized flaps on the tail fin. It also has black spots on the side of the body under the scales which the herring lacks. Both fish are silvery on sides and belly with dark blue or green dorsal surface. The sardines averaged 250 mm total length (TL) in the British Columbia fishery and were smaller as one progressed

southward. The largest specimen known was 394 mm long and weighed 486 grams (Hart 1973).

Distribution

The Pacific Sardine, previously known as *Sardinia* (or *Sardinops*) *caerula*, is also commonly referred to as the pilchard. It was distributed from northern Mexico to southeastern Alaska, although the main centres of concentration ranged from southern California — northern Baja to the southern portions of British Columbia (Figure 2). Whether or not there was a single panmictic population throughout this area or a series of moderately intermingling subpopulations remains a matter of contention (Felin 1954; Marr 1957; Murphy 1966; Culley 1971). The two prevailing hypotheses concerning stock structure are that: 1) there was a single major northern spawning

*Rare status approved and assigned by COSEWIC 7 April 1987.

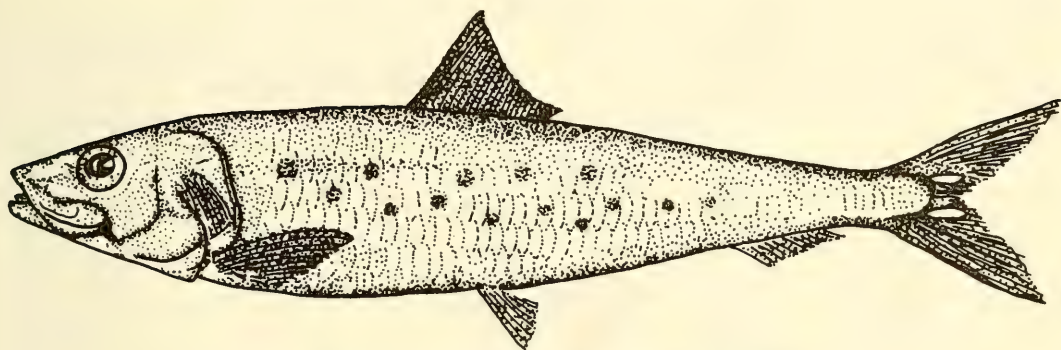


FIGURE 1. Pacific Sardine, *Sardinops sagax*, redrawn from Hart (1973).

population from San Francisco to San Diego which gave rise to fish which migrated successively farther north as they grew older, and 2) there was a now extinct far northern subpopulation which spawned at the northern extremity of the spawning area, the offspring of which moved northward to the fishing grounds of British Columbia and Washington as they matured.

It is clear from serological studies that there are presently three distinct races of sardine found in the Gulf of California (Vrooman 1964; Radovich 1982). However, since sardines had disappeared from the Pacific northwest by the late 1940s it is impossible to determine what the stock structuring may have been during this earlier period. It is evident that the far northern fish did not mix randomly with the southern fish, being larger, older, and having a higher growth rate and different scale patterns from the California fish (Felin 1954; Culley 1971). Other evidence indicates that the sardine restabilized at a much lower population level following the collapse of the Pacific northwest fishery, implying that there were distinct stocks in this area (Radovich 1962). There is also anecdotal evidence that some sardines overwintered in inlets on the west coast of Vancouver Island rather than migrating south in the fall (Hart 1938), so that they could conceivably have spawned farther north than is presently the case. For the present there is insufficient information to reject one stock hypothesis in favour of the other.

Protection

International: The main form of regulation in California covering most of the duration of the fishery consisted of season limits beginning in 1928. Other regulations consisted of net and mesh

size limits. In addition, considerable controversy revolved about the quantities of sardines which were reduced to oil and meal versus the amount canned for human consumption (Ahlstrom and Radovich 1970; Cully 1971). A permit system was introduced to limit the quantities reduced but the system was circumvented through various means — primarily reduction ships operating outside the three-mile territorial limit in effect at that time. Quotas had also been suggested at various times during the history of the fishery beginning in about 1931 but with limited success (Radovich 1982).

In 1967 the California Legislature imposed a moratorium on landings of Pacific Sardines for any purpose, including bait. It was recommended that fishing be suspended until the stocks rebuilt to at least 20 000 tons.

National: In British Columbia there was no restriction on the quantities that could be used for reduction as the fishery was seasonal and variable. Minor regulations of size and mesh of purse seine gear and season of fishing were imposed from time to time (Ahlstrom and Radovich 1970). The recent rare occurrence of sardines in Canadian waters has resulted in the absence of any regulations at present.

Population Size and Trends

The history of the fishery has been documented extensively by Murphy (1966), Cully (1971) and Radovich (1982). The fishery began in California in 1916-17 with a catch of about 25 000 tonnes primarily for the canned product to compete in the European markets where domestic production had been curtailed by the war (Table 1). The catch for reduction to meal and oil increased substantially thereafter peaking in 1936-37 at 718 000 tonnes. It

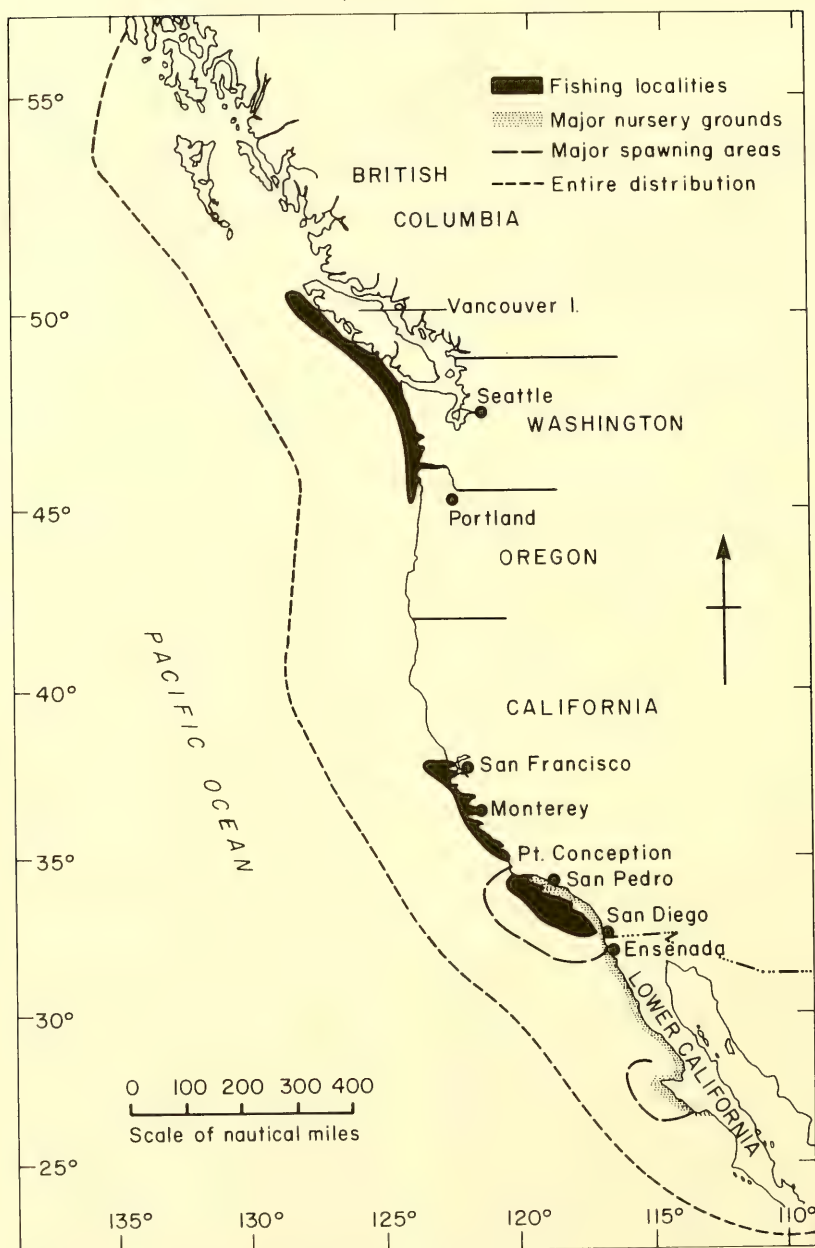


FIGURE 2. Distribution of the Pacific Sardine, its spawning grounds, nursery areas and major fishing localities prior to 1950 (redrawn from Culley 1971).

remained stable at about the 500 000 tonne level until 1945-46 when the fishery declined markedly to catches of 20 to 40 000 tonnes annually. It remained at this level until 1967 when legislation

was introduced to limit pressure on the depleted stocks (Radovich 1982). In 1973 a moratorium on landings was instituted until the spawning population rebuilds to 20 000 short tonnes.

The major reduction fishery began in 1925 which is coincident with the exponential growth in landings. In British Columbia this fishery began in 1917-18 at 70 tonnes and increased rapidly to 44 000 tonnes by 1926-27, a level that was surpassed and sustained until 1947-48 when 444 tonnes were landed (Radovich 1982).

The factors causing the demise of the sardine stocks are not well understood. During the period prior to 1950 there was a good relationship between year class strength and the cumulative water temperature (Radovich 1982). The poor year classes of 1949 and 1950 when environmental conditions were unfavourable were felt to be responsible for the demise of the stock given the heavy level of exploitation (Murphy 1966, 1978). By this time the stock age structure had been reduced to at most five age classes with the majority of fish being age 2 or younger (Murphy 1967). Thus the population had insufficient resilience to compensate for even two poor reproduction years so that by 1952 when favourable environmental conditions prevailed again the stock was so reduced that only a small year class could be produced (Murphy 1966, 1978; *see also* Iles 1973).

In addition, the available evidence indicates that the fishery took about 80 percent of the catch from the northern and, or far northern stocks. These stocks were vulnerable to the fishery in the Pacific northwest on their summer northward migration and were subsequently harvested in the California fishery during their fall southward migration (Murphy 1966). As the stocks were reduced, the spatial extent of the population appears to have contracted and the fishery began to rely more and more on immigration from the southern stock. After the poor production of the 1949 and 1950 year classes, dominance in the fishery switched completely to the southern stock which consisted of smaller, slower growing fish with a restricted age structure and possibly a higher natural mortality rate (Murphy 1966). This affected not only the estimated stock sizes but also biased estimates of the mortality rate, so that the decline in stock size appeared to be less drastic than it in fact was (MacCall 1979).

At about this time the Northern Anchovy (*Engraulis mordax*) populations were beginning to increase in size and it remains a matter of contention whether interspecific competition with the anchovy was responsible for, or accelerated, the demise of the Pacific Sardine stocks (Murphy 1966, 1978; Radovich 1982). In any event, it is interesting to note the relatively long time frame

(24 years) for stock recovery to maximum productivity estimated by Murphy (1967) in the presence of moderate fishing. The presence of the anchovy would be expected to delay this recovery for an unknown period of time.

Habitat

As for most marine fish species, little is known about specific habitat requirements of the Pacific Sardine. Sardines as a group are classified into three genera and about 18 species worldwide (Cully 1971). They are found in the waters of every continent although they are fundamentally a warm water species whose global distribution is restricted within the latitudes of 60°N and 50°S. California sardine schools have been found in temperatures ranging from 11°C to 20.4°C. The water temperature for spawning is thought to be restricted to the range 12.5° to 18°C. The temperature range for eggs seems even more restricted with virtually all eggs being found in water between 12.5° and 16°C. The food of the sardine is primarily copepods and diatoms. A combination of water temperatures and favourable feeding conditions may account for the annual northward migration of adult Pacific Sardine stocks each summer. Little is known about the requirements of juvenile sardines during their first summer when they are moved passively inshore and southward by the prevailing currents.

General Biology

There are presently two main spawning areas off southern California and Baja California. The northern spawning ground is located primarily between Point Conception and Ensenada (Figure 2). It is about 400 km long and extends up to 325 km offshore. The other spawning area is found off central Baja California and is about one half the size of the major spawning area. In addition, there is a spawning area within the Gulf of California which represents a separate but poorly studied group of fish. Spawning occurs both in the spring and fall. In the southern California offshore area spawning occurs between April and May at temperatures of 13 to 16.5°C. In the lower California area spawning is from March to April at similar temperatures. In this area there is also a fall spawning from August to September at temperatures of about 18 to 23°C. The fish of the Gulf of California are thought to spawn from February to March. Sardines with loose eggs have been found in Canadian waters but no spawning is known to occur here (Hart 1973). The Pacific Sardine are batch spawners with large fish (21 cm) releasing up

TABLE 1. Historical catch of sardines (tonnes) along the eastern Pacific coast up to the closure of reduction fishing in 1967 (season runs from 1 June to 31 May). Modified from Radovich (1982).

Season	Pacific Northwest					California				
	Northern California				Reduction Ships	California				Grand Total
	British Columbia	Washington	Oregon	Total		San Francisco	Monterey	Total	Southern California	
1916-17	—	—	—	—	—	—	6994	6994	17980	24085
1917-18	73	—	—	73	—	64	21600	21664	44180	65843
1918-19	3302	—	—	3302	—	408	32432	32840	35689	68529
1919-20	2976	—	—	2976	—	—	39045	39952	20856	60809
1920-21	3992	—	—	3992	—	209	22643	22852	12029	34881
1921-22	898	—	—	898	—	73	14778	14851	18262	33112
1922-23	925	—	—	925	—	100	26499	26599	32468	59067
1923-24	880	—	—	880	—	172	41658	41830	34310	76140
1924-25	1243	—	—	1243	—	508	61063	61571	95391	156961
1925-26	14470	—	—	14470	—	3193	74262	74455	60627	138083
1926-27	43999	—	—	43999	—	15141	88922	104063	65816	169879
1927-28	62079	—	—	62079	—	12265	109125	121390	109470	230860
1928-29	73038	—	—	73038	—	19922	145195	165117	129873	294989
1929-30	78326	—	—	78326	—	23560	99446	132948	34990	167938
1930-31	68102	—	—	68102	9943	19602	62667	110427	38936	216132
1931-32	66769	—	—	66769	28159	16904	81283	151521	75901	267656
1932-33	40234	—	—	40234	53333	32963	138328	232816	115025	351515
1933-34	3674	—	—	3674	61525	62121	209427	373190	166634	539824
1934-35	39009	—	—	39009	101641	69079	167348	373259	135217	508475
1935-36	4114	9	23795	64918	136831	128003	187521	529265	129463	658729
1936-37	40324	5951	12882	59158	213742	121307	95196	277811	100900	377901
1937-38	43618	15513	15114	74244	61308	182526	164195	386537	135355	521892
1938-39	46965	24022	15440	86428	39816	192734	206724	399458	87942	487400
1939-40	5008	16112	20257	41377	—	107131	257450	257450	160385	417835
1940-41	26100	735	2867	29701	—	169271	227057	396327	136529	532856
1941-42	54477	15513	14379	84368	—	105128	167284	272412	185409	457821
1942-43	59765	526	1769	62061	—	114770	193789	308559	125192	433751
1943-44	80504	9471	1651	91626	—	123920	215226	339146	164256	503402
1944-45	53633	18	—	53651	—	76297	132013	208310	157906	366215
1945-46	31116	2096	82	33294	—	2603	28477	31080	181022	212102
1946-47	3620	5570	3592	12782	—	85	15994	16079	94000	110079
1947-48	445	1234	6287	7965	—	102	43420	43521	123152	166673
1948-49	—	45	4826	4872	—	15823	119539	135362	172106	307468
1949-50	—	—	—	—	—	11546	30571	42117	278199	320316
1950-51	—	—	—	—	—	74	14422	14496	102625	117121
1951-52	—	—	—	—	—	—	—	—	—	14682

(continued)

TABLE 1. (Continued).

Season	Pacific Northwest				California					Grand Total		
	British Columbia	Washington	Oregon	Total	Northern California			Southern California	Total California			
					Reduction Ships	San Francisco	Monterey					
											Total	
1952-53	—	—	—	—	—	—	44	44	5136	5181	8312	13493
1953-54	—	—	—	—	—	—	53	53	4022	4075	12978	17053
1954-55	—	—	—	—	—	—	777	777	61334	62110	11285	73396
1955-56	—	—	—	—	—	—	470	470	67080	67550	3817	71366
1956-57	—	—	—	—	—	—	57	57	30463	30520	12388	42908
1957-58	—	—	—	—	—	—	15	15	20189	20205	29208	49003
1958-59	—	—	—	—	—	—	22408	22408	71913	94321	20261	114582
1959-60	—	—	—	—	—	—	14614	14614	19184	33798	19456	53254
1960-61	—	—	—	—	—	—	2123	2123	24075	26198	18052	44250
1961-62	—	—	—	—	—	—	2024	2024	21135	23159	19296	42454
1962-63	—	—	—	—	—	—	1099	1099	2686	3785	13263	17048
1963-64	—	—	—	—	—	—	921	921	1748	2669	16678	19347
1964-65	—	—	—	—	—	—	279	279	5257	5537	24603	30139
1965-66	—	—	—	—	—	—	137	137	515	652	20182	20834
1966-67	—	—	—	—	—	—	21	21	291	312	17718	18030
1967-68	—	—	—	—	—	—	—	—	64	64	25090	25154

to 25 000 eggs per spawning. A single such female appears to spawn about three such batches releasing almost 200 000 eggs per spawning season. Small fish, 13-15 cm, appear to spawn about 30 000 eggs per season.

Most spawning occurs during the first part of the night. Spawning behaviour varies from the norm as well with fish darting about excitedly and leaping out of the water. The eggs are about 1.6 mm in diameter and take about two to four days to hatch at 16 to 14°C. The eggs are deposited and fertilized in midwater and remain pelagic until hatching. Most of the eggs are found in the upper 25 m of the water column. The larvae are about 3.5 mm in length and resorb the yolk sac after four to seven days. By the end of two to three months they are about 34 mm and by the end of the first year 115 mm. The maximum length is about 31 cm for a fish 10 to 12 years of age and the females grow faster and larger than the males.

The instantaneous natural mortality rate has been estimated from age composition and tagging information at about 0.40 (Murphy 1966). The age of maturity is variable and appears to be a function of stock biomass. At large stock sizes only some of the two-year olds are mature while at low biomass all of the two-year olds appear to mature (MacCall 1979).

The young sardines move inshore as they grow and congregate in schools near beaches. Each year beginning in their second summer the fish migrate northwards early in summer and travel south again in the fall. Hart (1939, 1973) suggests that with increasing age the migration becomes farther with the oldest fish being found furthest to the north. The migrations appear to be complex, however, with timing and extent of movements being affected by oceanographic factors.

Limiting Factors

The factors determining the abundance of the sardine are not well understood. Environmental factors can and do affect the success of reproduction. Clearly, the fishery has had a dramatic effect on the distribution and abundance of sardines. Additionally, there have been speculations about the interrelationships of the sardine and anchovy populations both on short and long time scales from examinations of sediment cores (Soutar and Isaacs 1969, 1974). In general this data indicates that the anchovy has been present in the offshore California area for at least the past 200 years at a fairly uniform level of abundance. The Pacific Sardine on the other hand has enjoyed periods of great abundance

interspersed with periods of complete absence during this same time period. The available evidence thus suggests that the sardine is probably locally adapted to a narrower range of temperature for spawning and subsequent egg and larval development and survival than the anchovy. Any long term changes in ocean temperature regimes will naturally affect the success of reproduction and ultimately stock size to the extent that the sardine may be successful competitors with anchovy in restricted areas as the latter appear to be more tolerant of a wider range in temperature. The factors which affect the relative success of each of these species are clearly complex and so it is impossible to predict whether the presently extensive anchovy fishery can be expected to shift the balance in dominance back in favour of the sardine.

Evaluation

The question of whether or not Pacific Sardines may be expected to recover in Canadian waters to levels observed during the 1930s is a matter of speculation based on which of the prevalent hypotheses regarding their stock structure and population dynamics are correct. If a genetically distinct subpopulation really existed in northern waters as suggested by Felin (1954), Radovich (1962, 1982), and Vrooman (1964) then it is unlikely that we will see large quantities of sardines in the northwest Pacific in the short term unless there is large scale recolonization from more southerly waters. If a genetically distinct far northern subpopulation or population did exist and is now extirpated it may be decades, or hundreds, or thousands of years before a new population re-evolves, if it ever does. On the other hand, if the fish found in the British Columbia area earlier this century were northern migrants from the California stock then there is certainly the opportunity for a rebuilding of these stocks which appears to be in progress (R. Klingbiel, California Department of Fish and Game, Sacramento, California; personal communication). Similarly, there has been an upsurge of the Pacific Sardine in Japanese waters in recent decades (Kondo 1980). As stock sizes increase and the age structure changes to more older fish one would expect to see more sardines in northern waters. The extent and frequency of these occurrences will be affected by oceanic conditions; warm el Niño periods are apt to bring such a southern species farther to the north (Fulton and Lebrasseur 1985). The speed with which the sardine population rebuilds and hence arrives in our waters may also be dependent

on the size of the anchovy stocks. Trends in the relative abundance and distribution of these species during the next few decades should provide good evidence to support or refute the two hypotheses describing Pacific Sardine stock structure and population dynamics.

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Status of the Sea Mink, *Mustela macrodon*, in Canada*

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The Sea Mink (*Mustela macrodon*) had probably been exterminated by 1894, prior to its recognition by Prentiss in 1903 as a distinct species. Its scientific description was based on skeletal and skull fragments found in Indian shell heaps in Maine. The Sea Mink was probably a solitary, nocturnal animal frequenting the rocky coasts of the northeast Atlantic seaboard from Connecticut to New Brunswick and, possibly, Newfoundland. Males were at least twice as large as the American or Common Mink (*Mustela vison*) and females larger than males of the Common Mink. The fur was reddish-brown and coarser than that of the Common Mink and the animals had a distinct, offensive odour. Populations were probably never large and the known range was limited to the New England — Bay of Fundy coast. The pelts fetched high prices during the 1800s and exploitation for the furs no doubt contributed to the early demise of the species.

Le Vison de mer (*Mustela macrodon*) a probablement été exterminé vers 1894, avant d'être reconnu comme espèce distincte par Prentiss en 1903. Pour décrire l'espèce, on s'est basé sur des restes de squelettes et de crânes trouvés dans des amas coquilliers des indiens du Maine. Le Vison de mer était probablement un animal nocturne et solitaire qui fréquentait les côtes rocheuses du littoral de l'Atlantique nord-est depuis le Connecticut jusqu'au Nouveau-Brunswick et, peut-être, au Terre-Neuve. Les mâles avaient au moins deux fois la taille du Vison d'Amérique (*Mustela vison*) et les femelles étaient plus grosses que les mâles de cette espèce. La fourrure était brun rougeâtre et plus rude que celle du Vison d'Amérique et ces animaux exhalaient une odeur nauséabonde caractéristique. Les populations n'ont probablement jamais été importantes et l'aire de dispersion, bien qu'inconnue, se limitait à la région de la Nouvelle-Angleterre et de la côte de la baie de Fundy. Les peaux ont atteint un prix élevé au cours des années 1800 et l'exploitation de l'espèce pour sa fourrure a certainement accéléré sa disparition précoce.

Key Words: Sea Mink, *Mustela macrodon*, mustelids, extinct species.

The Sea Mink (*Mustela macrodon*) (Figure 1) was probably a solitary, nocturnal animal frequenting the rocky coasts of the northeast Atlantic seaboard from Connecticut to New Brunswick and, possibly, Newfoundland. Males were at least twice as large as the American or Common Mink (*Mustela vison*) and females larger than males of the Common Mink. The fur was reddish-brown and coarser than that of the Common Mink and the animals had a distinct, offensive odour. Populations were probably never large and the restricted range seems to have been limited to the New England — Bay of Fundy coast.

Distribution

The exact extent of the range of the Sea Mink is unknown as the species was thought to be exterminated prior to 1900 and its recognition as a distinct species by Prentiss (1903). The only records of the species are of skeletal fragments and skulls found in Indian shell heaps along the New England coast (Prentiss 1903; Banfield 1974) and

anecdotal accounts (Wright 1962). It is probable that the range was at least from Connecticut northward to the Bay of Fundy and, possibly, Newfoundland, as suggested by Pennant (1785). The only verified Canadian record is also the last known specimen of this animal; taken at Campobello, New Brunswick in 1894.

Protection

There are no specific protective measures in place in Canada or the United State as the species has been thought to be extinct since 1894.

Population Size and Trends

Nothing is known of the nature and size of populations of this animal and no living or freshly killed specimen was ever examined by a biologist. Wright (1962) reported that, due to their size, the pelts brought a good price on the fur markets and the species was much sought after. The few accounts available (Pennant 1785; Wright 1962) suggest that the animals were perhaps never

*Extinct status approved and assigned by COSEWIC April 1985.

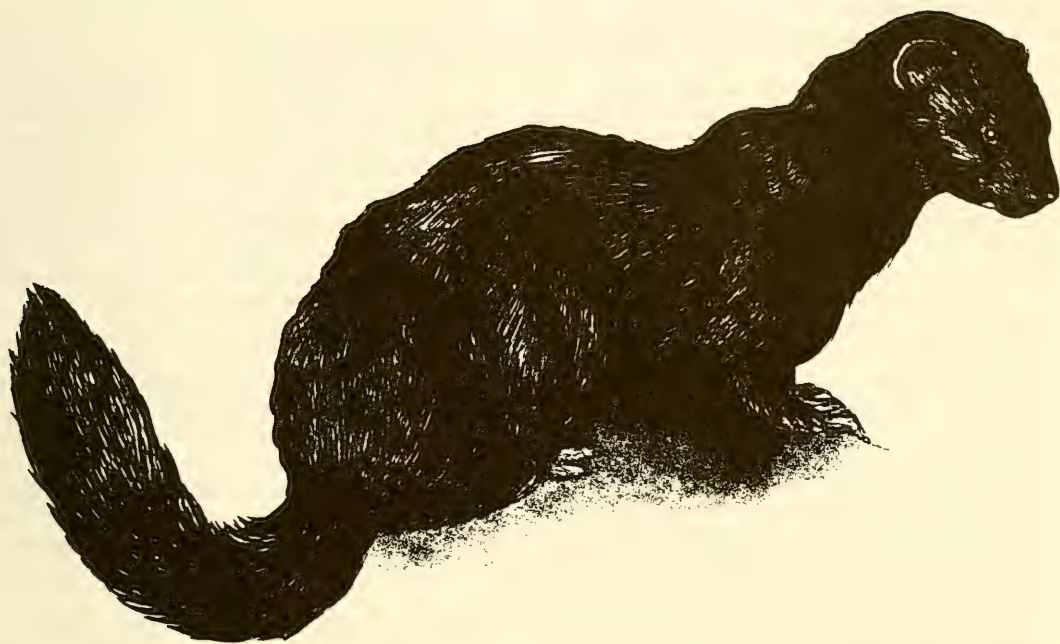


FIGURE 1. Drawing of the Sea Mink, *Mustela macrodon*. (Drawing by J-C. Campet, courtesy Department of Fisheries and Oceans)

abundant and much effort was required in hunting the species. It quickly disappeared once the value of the pelts was recognized.

There have been occasional sightings of minks much larger than the Common or American Mink in the Bay of Fundy area (see Wright 1962) which may be elusive survivors of this species. Such sightings are few and far between and none were verified. None have been reported since 1942.

Habitat

The Sea Mink occurred along the rocky coasts and offshore islands of New England north to the Bay of Fundy and, possibly, Newfoundland, a habitat now occupied by the American Mink. Although no studies of their biology were made, it appears that Sea Minks preferred coastal habitats where tidal pools offered crabs, fish, and seabirds as a source of food.

General Biology

Nothing is known for certain regarding the biology of the species, its habits, reproductive capabilities or movements.

Wright (1962) offers some hints based on anecdotal accounts which indicate that, like the

American Mink, the species was solitary and nocturnal and that it spent much of its time at sea, more like the Sea Otter (*Enhydra lutris*) than a mink. Wright (1962) suggests that litters were 5 to 6 kits, born in May or June, and were soon independent of the mother, quickly adopting the solitary life and coming together only to mate. Adult females were described as being about the same size, or slightly larger than, the American Mink and males twice as big (Wright 1962; Banfield 1974). Growth must have been rapid if maturity was reached at ten months, as suggested by Wright (1962).

They differed from the American Mink not only in over-all size but in colour and in size of the teeth and skull (Prentiss 1903; Banfield 1974). They were also said to have had a peculiar smell (Wright 1962; Banfield 1974). Two sub-species of *Mustela vison*, *Mustela vison lutrecephalus* and *Mustela vison injens*, still found in Alaska, are coastal in habitat, but they are definitely smaller (Prentiss 1903; Wright 1962).

Limiting Factors

Since no detailed accounts of the habitat or biology of the species exist, one can only speculate

on factors leading to its demise, based on the accounts given by Wright (1962) and Banfield (1974). Critical habitat may have been important.

At one time populations may have been widespread since hundreds of miles of coastal habitat were available around Nova Scotia and the Gulf of St. Lawrence. Despite this, no records exist of the animals having been hunted, or seen, beyond the more limited range described above nor have fossil or skeletal fragments been reported elsewhere.

The rapid and early demise of a species, reported to have been difficult to hunt (Wright 1962), is more typical of a very limited population, restricted by some critical ecological factor. It is evident, however, that the fur trade was probably responsible for the final extermination of the species.

Special Significance of the Species

The Sea Mink was a unique species of the northeast Atlantic coast, most probably more like a Sea Otter in its habits (with the exception of its solitary nature) than the Common or American Mink. It is possible that the species was not generally identified by trappers as differing from the Common Mink during the heyday of the fur trade, but this seems unlikely as Pennant (1785) noted its distinctness (although he could not identify it) and it was markedly larger and of a different colour than the Common Mink, with coarser fur and a distinct smell (Wright 1962). Moreover, fur buyers recognized the pelts and paid a special price (Banfield 1974) which might go to \$8–\$10 (prior to the 1870s). No records of the

extent of the trade in pelts are available but it could not have been large or more accurate records would have been kept.

Today the real significance of the species may be related to its disappearance prior to its recognition as a distinct species or to any offer of protection, a lesson similar to that offered by the Labrador Duck (*Camptorhynchus labradorius*) or the Great Auk (*Pinguinus impennis*). Such examples have resulted in the profound movement for the conservation of fish and wildlife as a legacy of man, yesterday, today, and tomorrow.

Evaluation

There is very little likelihood of any surviving members of this species. The last verified specimen was killed in New Brunswick in 1894. Subsequent "sightings" have not been confirmed and may have been large *Mustela vison*. Banfield (1974) listed the species as extinct since 1894. Prentiss (1903) also considered the species extinct in his original description.

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Status of the California Sea Lion, *Zalophus californianus*, in Canada*

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The California Sea Lion is seen in British Columbia during September-May, primarily off Vancouver Island. Only adult and subadult males are found here. The species was rare in British Columbia between the late 1800s and the 1960s, and was confined to southwestern Vancouver Island. In the 1970s, the range expanded into waters off southeastern Vancouver Island. Total numbers increased from about 500 animals in 1972 to 4 500 in 1984, with most of the increase taking place since 1980.

L'Otarie de Californie fréquente les eaux de la Colombie-Britannique, plus particulièrement celles situées au large de l'île de Vancouver, de septembre à mai. Fait à souligner, on n'y observe que des mâles adultes et de jeunes mâles. Entre la fin des années 1800 et les années 1960, l'espèce était considérée comme rare en Colombie-Britannique et elle était surtout confinée aux eaux du sud-ouest de l'île de Vancouver. Au cours des années 1970, l'aire de répartition de l'espèce s'est élargie aux eaux situées au sud-est de l'île de Vancouver. Le nombre d'animaux est passé d'environ 500, en 1972, à 4 500, en 1984; l'augmentation est devenue plus marquée à partir de 1980.

Key Words: California Sea Lion, *Zalophus californianus*, seals, North Pacific.

Three stocks of California Sea Lions (*Zalophus californianus*) inhabit the coastal waters of the North Pacific Ocean (Scheffer 1958; King 1983). The largest stock breeds in Mexico and California, and has a non-breeding range northward to British Columbia. A small population is also found on the Galapagos Islands and another off Japan, although the latter stock may be extinct. During the 1800s and early 1900s California sea Lions (Figure 1) were hunted throughout their range for blubber, meat, hides, and various organs as well as for predator control on commercial fisheries. In British Columbia, little killing took place in the 1900s because the species was rare here during this time. However, since the early 1970s, numbers have increased and so have complaints from fishermen about interference with fishing operations and damage to gear and stocks of herring, squid, and cod.

Studies that report on the status of California Sea Lions in British Columbia include Newcombe et al. (1918), Wailes and Newcombe (1929), Hancock (1970), Guiguet (1971), Hatler (1972), and Bigg (1973, 1984, 1985). In this paper the current status of the species in British Columbia is described based largely on extracts from Bigg (1985).

Distribution

The main distribution of California Sea Lions in British Columbia is off Vancouver Island, from the Barkley Sound area southward to Race Rocks and northward to Denman Island (Figure 2). A small group also occurs at Solander Island. The sites at which this species congregates are haulouts and rafting areas. Rafting occurs mainly in the area of Porlier Pass and Plumper Sound. In the late 1960s, the species was found in small numbers only in Barkley Sound and at Race Rocks (Hancock 1970, Guiguet 1971). During the 1970s, the range extended gradually into southeastern Vancouver Island with the main concentration eventually being in the vicinity of Plumper Sound and Porlier Pass. The colonization sequence into southeastern Vancouver Island was as follows: Porlier Pass in 1972, Ada Island in 1973, Sand Heads in 1978, and Denman Island in 1979. By 1973, the range extended north of Barkley Sound to Solander Island. A few individuals are seen occasionally at more northerly sites in British Columbia, such as Triangle Island, Cape St. James, and Joseph Rocks. Small numbers (100) exist also in eastern Washington, at Sucia Island and Port Gardner (Everitt et al. 1980; Bigg 1984).

*Status reviewed by COSEWIC and the species was determined not to be in jeopardy in Canada and not in any COSEWIC category 7 April 1987.



FIGURE 1. Adult male California Sea Lions (Photograph by the author).

Off southeastern Vancouver Island, California Sea Lions are seen usually at sites with Steller Sea Lions (*Eumetopias jubatus*). However, off western Vancouver Island, California Sea Lions are seen at

only a few sites occupied by Steller Sea Lions. During numerous censuses in winter between Race Rocks and Solander Island, California Sea Lions were rarely found at Carmanah Point, Pachena

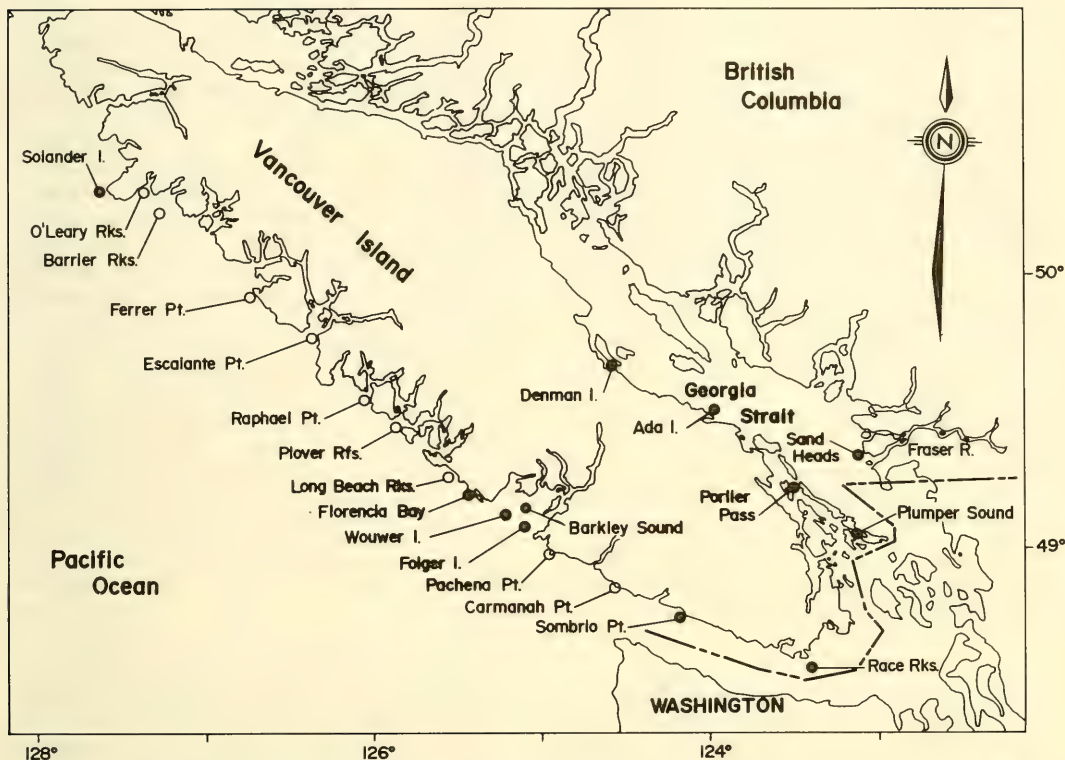


FIGURE 2. Geographical locations of the main haulout and rafting sites used by California Sea Lions (●) off Vancouver Island, and sites used only by Steller Sea Lions (○).

Point, Long Beach Rocks, Plover Reefs, Raphael Point, Escalante Point, Ferrer Point., Barrie Rocks, and O'Leary Rocks (Figure 2). These sites are occupied typically by 50-250 Steller Sea Lions in winter. California Sea Lions appeared to avoid sites that are exposed directly to oceanic swells. Large swells do not occur off southeastern Vancouver Island, but do occur off western Vancouver Island where they can be large, particularly in winter. Sites occupied by California Sea Lions off western Vancouver Island tend to be on the leeward side of islands. Individuals are often seen in ravines, and sometimes even at the base of trees and shrubs, where Steller Sea Lions are not typically seen.

Protection

The species is protected in U.S. waters under the Marine Mammals Protection Act of 1972 and in Canada since 1970 under the Federal Fisheries Act. However, the species may be taken in British Columbia under certain conditions specified by the

Regional Director General of the Department of Fisheries and Oceans. No hunting of California Sea Lions has been permitted in Canada since 1970.

Population Size and Trends

The number of California Sea Lions in British Columbia was very low during the early 1900s, and has increased noticeably only in recent years. Newcombe and Newcombe (1914) and Newcombe et al. (1918) did not observe the species, but did cite accounts of it in Barkley Sound during the late 1800s and early 1900s. So uncertain was the evidence for occurrence that Wailes and Newcombe (1929) later stated that no proof existed for the species in British Columbia. However, Guiguet (1953) established proof of early presence with the discovery of a skull collected just north of Barkley Sound in the late 1800s. He also reported small numbers seen by fishermen in Barkley Sound during winter in the mid-1950s, and noted an apparent increase in numbers during the 1960s

TABLE 1. Number of California Sea Lions seen off Vancouver Island during 1972 to 1984.

	1972 25 Feb.	1973 25 Jan.	1977 7-9 Feb.	1978 9 Feb.	1982 17-22 Feb.	1984 15-16 Feb.
SE Vancouver Island						
Race Rocks	35	38	70	13	320	799
Plumper Sound Area	0	0	10	30	220	53
Porlier Pass Area	10	0	0	0	418	764
Ada Island	0	0	29	58	39	84
Denman Island	0	0	0	0	20	0
Other	0	0	0	0	4	2
Subtotal	45	38	109	101	1021	1702
SW Vancouver Island						
Sombrio Pt	1	—	16 ^b	—	—	93
Folger Island	387	0	152 ^b	—	12	0
Wouwer Island	40	—	8 ^b	-	415	839
Florenca Bay	—	—	—	—	+	1777
Solander Island	0 ^a	33	40 ^b	—	—	50
Other	0	0	2 ^b	—	72	35
Subtotal	428	218	499+	2794		
Total	473	327	1520+	4496		

^a7 December 1971.
^b13 December 1976.

(Guiguet 1971). The Canadian Department of Fisheries and Oceans undertook extensive surveys for Steller Sea Lions during winter in the 1950s and 1960s, and reported that only a few California Sea

Lions were observed, all in the vicinity of Barkley Sound. By the late 1960s, a small colony had formed at Race Rocks (Hancock 1970), and up to 300 were reported in Barkley Sound in the winter

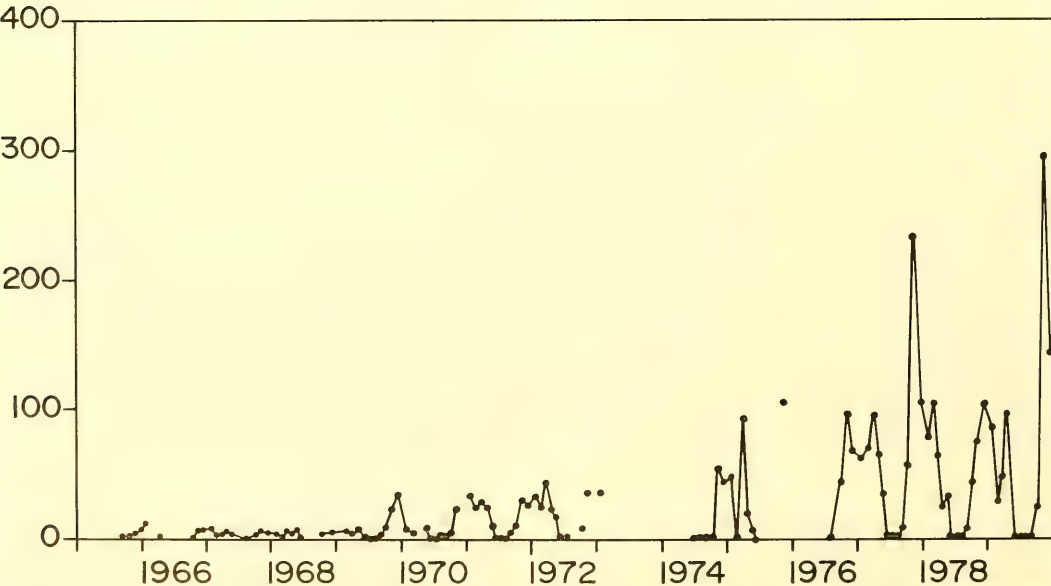


FIGURE 3. Monthly mean maximum number of California Sea Lions seen at Race Rocks during 1965 to 1979 recorded mainly by the light house keeper, T. Anderson (Bigg 1985).

of 1970-71 (Hatler 1972). In 1972, a colony of 400 was found at Folger Island (Bigg 1973). Censuses off Vancouver Island during 1972 to 1984 suggest that numbers increased slightly between 1972 and 1978, but increased sharply by 1982, and again by 1984 (Table 1).

The main increase in numbers off southeastern Vancouver Island took place at Race Rocks, Plumper Sound, and Porlier Pass. A decrease in the number of California Sea Lions was seen at Plumper Sound between 1982 and 1984. The decrease may have been due to reduced numbers of herring (*Clupea harengus pallasii*) there at this time (R. Armstrong, Department of Fisheries and Oceans, Vancouver, British Columbia; personal communication). However, herring remained numerous at Porlier Pass during this time, as did this sea lion. Confirmation of the trend in increasing numbers of California Sea Lions during the 1970s comes from daily counts taken at Race Rocks during 1965-79 (Figure 3). The species was not present before the mid 1960s. Between 1970 and 1979, the number of animals progressively increased.

Counts at sites off western Vancouver Island were not as complete during each survey as those off southeastern Vancouver Island, and the counts were not always comparable in timing between years. An important site missed until 1984 was Florencia Bay. In 1984, it had the largest number of California Sea Lions present of any site off Vancouver Island. Although Steller Sea Lions also haul out there, this site contains mainly California Sea Lions. Information on the history of sea lions at this site comes from observations by D. Girodet (Field Services Branch, Department of Fisheries and Oceans, Vancouver, British Columbia; personal communication). During annual aerial surveys for herring in winter, he noted only 10 to 20 sea lions of uncertain species were present on this haulout during 1975-1979. Beginning in 1980, he observed that "hundreds" were present.

The number of California Sea Lions off Vancouver Island increased 10-fold between 1972 and 1984, with most of the increase apparently taking place since 1980. The species did not increase the northern range in association with the sharp increase in numbers since the late 1970s. None was seen during an aerial survey for Steller Sea Lions around northern Vancouver Island, from Denman Island to Solander Island, during 7 March 1984.

Habitat

After breeding in May-June off California and Mexico the females remain to the south of central California and the males migrate northward (Orr

and Poulter 1965; Peterson and Bartholomew 1967; Morejohn 1968). The sites at which the species congregate off Vancouver Island are winter haulouts and rafting areas as described for the Steller Sea Lion (Bigg 1985). The two species may often be found in the same areas during winter.

The haulout areas are found in exposed locations, and in sheltered inlets and channels. Sites in exposed locations generally are not exposed directly to oceanic swells, but rather are sheltered to some extent by the surrounding topography, such as within a bay, or on the leeward side of an island. Occupancy can be continuous or intermittent. Sites where less than about 50 animals haul out are used least frequently.

Where no suitable haulout site is available, California Sea Lions rest on the water surface in a tightly packed group, or raft. Rafting sites are found mainly close to shore in sheltered inlets and channels, but occur sometimes in exposed localities. The exact location of rafts may change by several miles during the winter, perhaps in response to changes in the location of the food supply.

General Biology

Reproduction and Life History: Little information is available on the reproductive biology and physiology of the species. The pups are born from May through July in the California rookeries (Peterson and Bartholomew 1967; Odell 1981). Copulation is thought to occur about three weeks after pupping (Odell 1981) with a gestation period of about 11 months. No information is available on the age of sexual maturity. Lluch-B (1969a) indicates that males may be sexually mature at nine years and females at 6-8 years although both sexes may not be physically mature at this time. Longevity, age, and sex-specific mortality rates, are unknown.

Zalophus, and other sea lions, demonstrate an extreme degree of sexual dimorphism. Adult males may weigh up to 390 kg and reach lengths of 2.2 m whereas the females may average 110 kg in weight and 1.8 m in length (Lluch-B 1969a). Very little information is available on the growth of the species although Lluch-B (1969a,b) does describe growth of animals from the Gulf of California. New-born pup weight has been found to average from 6.7-9.0 for males and 6.0-7.7 kg for females (Lluch-B 1969a,b; Odell 1972).

Sex ratios on the rookeries have been established on San Nicolas Island California by Odell (1972, 1975). Adult females were found to be in a ratio of 16:1 to territorial males and pups were 1:1 (female pups to male pups).

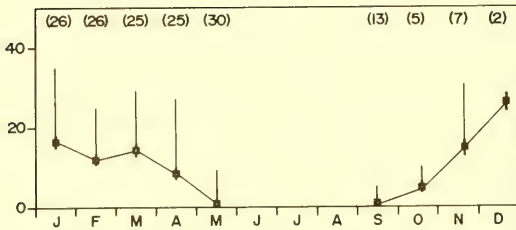


FIGURE 4. Monthly mean, standard error of the mean, and maximum number of California Sea Lions counted at Race Rocks by the light house keeper, T. Anderson during 1971. Number of days of observation shown in parentheses.

Seasonal Movements: Daily counts made in 1971 by lighthouse keeper T. Anderson (Figure 4) at Race Rocks suggest arrivals begin in September, and departures are complete by late May. No animals are present between June and August. Based on the mean and maximum numbers seen during 1971, most animals had arrived by November. Daily counts during other years between 1967 and 1979 (Bigg 1984), while less complete, indicate basically the same arrival and departure schedule.

An inspection of numerous sitings of California Sea Lions in Georgia Strait (Bigg 1984) indicate arrival in this more easterly area during October-November slightly later than at Race Rocks. At Sand Heads, records from lighthouse keepers and fishery officers during 1978 to 1982 indicate that arrivals began in mid-March, numbers reached a peak in late April-early May, and departures were completed by late May. The site was apparently used by this species, along with the Steller Sea Lion, to feed on Eulachon (*Thaleichthys pacificus*) that spawn in the nearby Fraser River at this time. Also, in late April 1984, a fishery officer saw about 120 California Sea Lions 50 km up the Fraser River.

The observed time of arrival of California Sea Lions off southern Vancouver Island coincides with the predicted schedule, based on movement patterns recorded in more southern locations. After breeding in May-June off California and Mexico, females remain south of central California, while males migrate northward (Orr and Poulter 1965; Peterson and Bartholomew 1967; Morejohn 1968). The northward migration of males between California and British Columbia has been plotted by Mate (1975). Using his observations, the main arrival time of males at Race Rocks should be November, as Bigg (1985) indicated. Also as expected, only adult and

subadult males have been observed in British Columbia at Folger Island, Race Rocks, Ada Island, and Sand Heads. Hancock (1970) reported only males at Race Rocks.

Food and feeding: The main prey species as listed by Odell (1981) are Northern Anchovy (*Engraulis mordax*), Hake (*Merluccius productus*), rockfish, octopus and the Squid (*Loligo opalescens*). Salmon, rockfish, flatfish, small sharks and cephalopods have also been reported (Morejohn 1977; Antonelis et al. 1984) from stomach contents and scats. Off Vancouver Island this sea lion is usually found in association with schooling herring in winter.

California Sea Lions may feed diurnally and nocturnally (Peterson and Bartholomew 1967). They may also feed in large groups, much like the Steller Sea Lion (Schusterman 1981), when large schools of fish and squid are present (Fiscus and Baines 1966). Feeding groups tend to be smaller in the absence of large schools of prey (Peterson 1968).

Behaviour: Breeding males establish and defend territories at about the same time as females arrive (Peterson and Bartholomew 1967). The territories are maintained by stereotyped boundary displays which rarely result in physical damage to approaching males (Peterson and Bartholomew 1967; Odell 1972). Territories on rocky areas may be stable throughout the breeding period (Odell 1972), but in areas of open sandy beaches lacking major topographic features, territories may shift with time of day, location of females, tide and temperature (Peterson and Bartholomew 1967). The mean period of territorial maintenance was 27 days (Odell 1972).

The female/pup bond is formed at birth through vocalization of the female and the smell of the pup (Odell 1981). The duration of lactation is unknown but females have been observed with nursing yearlings (Peterson and Bartholomew 1967; Odell 1972). The females copulate within three weeks of parturition, the female actively soliciting the male and terminating copulation.

Limiting Factors

An increase in the number of California Sea Lions in British Columbia was expected over the past 50 years, because the breeding population off California has grown steadily. Only about 400 to 1 000 California Sea Lions were seen off southern California during the early 1930s, following severe depletion as a result of commercial exploitation (Bonnot 1928; Bartholomew and Boolootian 1960). Thus, few animals could have migrated into British Columbia early in this century. By 1975, the

population off southern California had increased to at least 27 000 (Mate 1977), and since then has continued to increase at a rate of about 5% per year (DeMaster et al. 1982).

The increase observed off Vancouver Island during the 1980s was much larger than the annual rate of increment for the breeding population off California. Hence, a sudden shift to more northern migrants appears to have taken place in the southern population. One possible explanation is that the population in wintering areas south of British Columbia grew past a critical level of crowding or competition for food and as a result some males suddenly shifted their winter distribution more northward. DeMaster et al. (1982) suggested growth of the breeding stock may be slowing due to density dependent factors. Perhaps in approaching maximum numbers, the population expanded the use of the northern range. If this explanation is correct, then the size of the population in British Columbia can be expected to continue increasing in the future if the breeding population off California also continues to increase in size. Another possibility is that recent increases in coastal water temperatures encouraged the species to move more northward. Bartholomew (1967) suggested that the northern limit of the breeding range of the species was restricted to southern California by warm water distribution. In 1982-83, the El Niño current caused a more northerly flow of warm water from tropical areas to the coast of British Columbia (Tabata 1984). A longer warming trend also took place along coastal waters of British Columbia between about 1972 and 1981 (Dodimead 1984). Temperature could influence the winter distribution of California Sea Lions through changes in food supply or changes in the metabolic costs of thermoregulation. If increased water temperatures caused the numbers of this species to increase in British Columbia, then numbers should decrease over the next few years. El Niño is now diminishing, and a decreasing trend in the long-term temperature of coastal waters is expected.

Special Significance of the Species

The California Sea Lion is widely known as the trained "seal" of circuses and marine displays and may be one of the best known of all pinnipeds. The species was brought to very low numbers by heavy commercial exploitation off Mexico and California prior to the 1930s. The small population that resides off Japan may be extinct. In British Columbia waters the species is a matter of concern to fishermen who view increasing sea lion populations as a threat to the fish resources upon which they depend for their livelihood. However,

the California Sea Lion is found in Canadian waters only in the winter and the main conflict is with the herring fishery.

Evaluation

The species was rare in British Columbia from the late 1800s to the late 1960s. It gradually increased in numbers during the 1970s, and rapidly grew during the 1980s. Depending on the cause of the sharp recent increases, the species can be expected to either continue increasing or begin to decrease to low numbers again. Because of the present upward trend in numbers the population is not in jeopardy in Canada, it is recommended that California Sea Lions not be given any COSEWIC status at this time.

Acknowledgments

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Status of the Steller Sea Lion, *Eumetopias jubatus*, in Canada*

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During this century Steller Sea Lions occupied eight rookeries, 15 year-round haulouts, and at least 50 winter haulouts and winter rafting areas along the coast of British Columbia. Rookeries are occupied throughout the year with a peak in numbers during July. Year-round haulouts show no marked seasonal variation in number of individuals seen. Winter sites are occupied primarily in winter, although sometimes during August-May. The trend in numbers of Steller Sea Lions on a rookery depends mainly upon the size of kills made at the rookery. Early census data suggests that a total of 11 000 to 14 000 animals of all ages were seen on rookeries in 1913. A series of culls during the period 1913 to 1968 resulted in a series of population declines. By 1971 to 1982, numbers averaged only 3 800 on rookeries and 1 900 on year-round haulouts. Most animals appear to move seasonally between local rookeries and winter sites, with some immigration and emigration likely.

Au cours du présent siècle, les Otaries de Steller ont occupé le long de la côte du Colombie Britannique huit roqueries, 15 aires de repos permanentes et au moins 50 aires de repos sur terre et en mer utilisées pendant l'hiver. Les roqueries sont occupées tout au long de l'année et le nombre d'otaries présentes atteint un maximum en juillet. Les aires de repos permanentes ne présentent pas de variations saisonnières marquées quant au nombre d'otaries dénombrées. Les aires d'hiver sont surtout occupées en hiver, bien qu'elles le soient aussi parfois d'août à mai. Le nombre d'otaries de Steller présentes dans un roquerie donnée est en grande partie fonction du nombre d'animaux abattus à cet endroit. Selon les inventaires antérieurs, de 11 000 à 14 000 animaux de tous âges étaient présents sur les roqueries en 1913. Les abattages effectués de 1913 à 1968 se sont traduits par une série de baisses de la population. De 1971 à 1982, on ne comptait en moyenne que 3 800 otaries sur les roqueries et 1 900 dans les aires de repos permanentes. La plupart des animaux semblent se déplacer de façon saisonnière entre leurs roqueries et les aires d'hiver bien qu'il soit probable qu'il y ait, dans une certaine mesure, immigration et émigration.

Key Words: Steller Sea Lion, *Eumetopias jubatus*, pinnipeds, seals, North Pacific.

The Steller Sea Lion (*Eumetopias jubatus*) inhabits the coastal waters of the North Pacific Ocean from California to the Bering Sea and Japan (Scheffer 1958; King 1983). The species is well known throughout its range largely because of the damage which it causes to commercial fish and fishing gear. The result of this damage has been control programs in many regions. In British Columbia, long-standing complaints come mainly from salmon, herring, and halibut fishermen. Fisheries agencies of the Canadian government responded with population control programs that extended from 1913 to 1968. These programs involved bounties, organized culls, and commercial takes for meat, blubber, and hides.

The main studies that report on the status of this sea lion (Figure 1) in British Columbia include Newcombe and Newcombe (1914), Newcombe et al. (1918), Wailes and Newcombe (1929), Pike and Maxwell (1958), Pike (1966), Smith (1972), Edie

(1977), and Bigg (1984, 1985). This report describes the current status of Steller Sea Lions in British Columbia based largely on extracts from Bigg (1985).

Distribution

Steller Sea Lions are found in Canada along the coast of British Columbia (Figure 2). Generally they are found within 5 miles from shore, although they are known to occur up to 85 miles offshore (Fiscus and Baines 1966). Much of the population remains in exposed coastal locations, while some animals enter inlets and protected waters.

Steller Sea Lions in British Columbia congregate at four kinds of sites which are further discussed under habitat.

1. *Rookeries*. These sites are located farthest from land masses (Figure 2). Essentially all births and breeding takes place there. Some animals are usually present throughout the year (Table 1).

*The status of the species was reviewed by COSEWIC 7 April, 1987, and it was decided that the species was not in jeopardy in Canada or in any COSEWIC category.



FIGURE 1. Adult male Steller Sea Lion (*Eumetopias jubatus*). Photograph by the author.

2. *Year-round haulouts.* These are usually located close to land masses. Animals are present year-round with no marked seasonal variation in numbers seen.

3. *Winter haulouts.* These are found in exposed locations, similar to those of year-round haulouts, and in sheltered inlets and channels. The main period of occupancy is winter, although sea lions are present sometimes from August to May. Occupancy can be continuous or intermittent.

4. *Winter rafting sites.* Where no suitable haulout site is available, sea lions rest on the water surface in a tightly packed group, or raft.

Protection

The species is protected in U.S. waters under the Marine Mammal Protection Act of 1972 and in Canadian waters since 1970 under the Federal Fisheries Act. Steller Sea Lions can be taken in

Canada only under certain conditions that must be approved by the Regional Director General of the Department of Fisheries and Oceans. No hunting of Steller Sea Lions has been permitted since 1970.

Population Size and Trends

Numbers on Rookeries: The precise pattern of seasonal variation in numbers on rookeries must be understood before annual trends in numbers can be determined. A review of existing knowledge about seasonal variations is worth incorporating here because much of this information is found only in reports that are not easily accessible, and has not been summarized. The pattern of seasonal variation appears to be the same throughout the range of the species. The number of animals on rookeries is typically largest during summer and smallest during winter (Orr and Poulter 1965; Gentry 1968, 1970; Calkins and Pitcher 1982). Pike

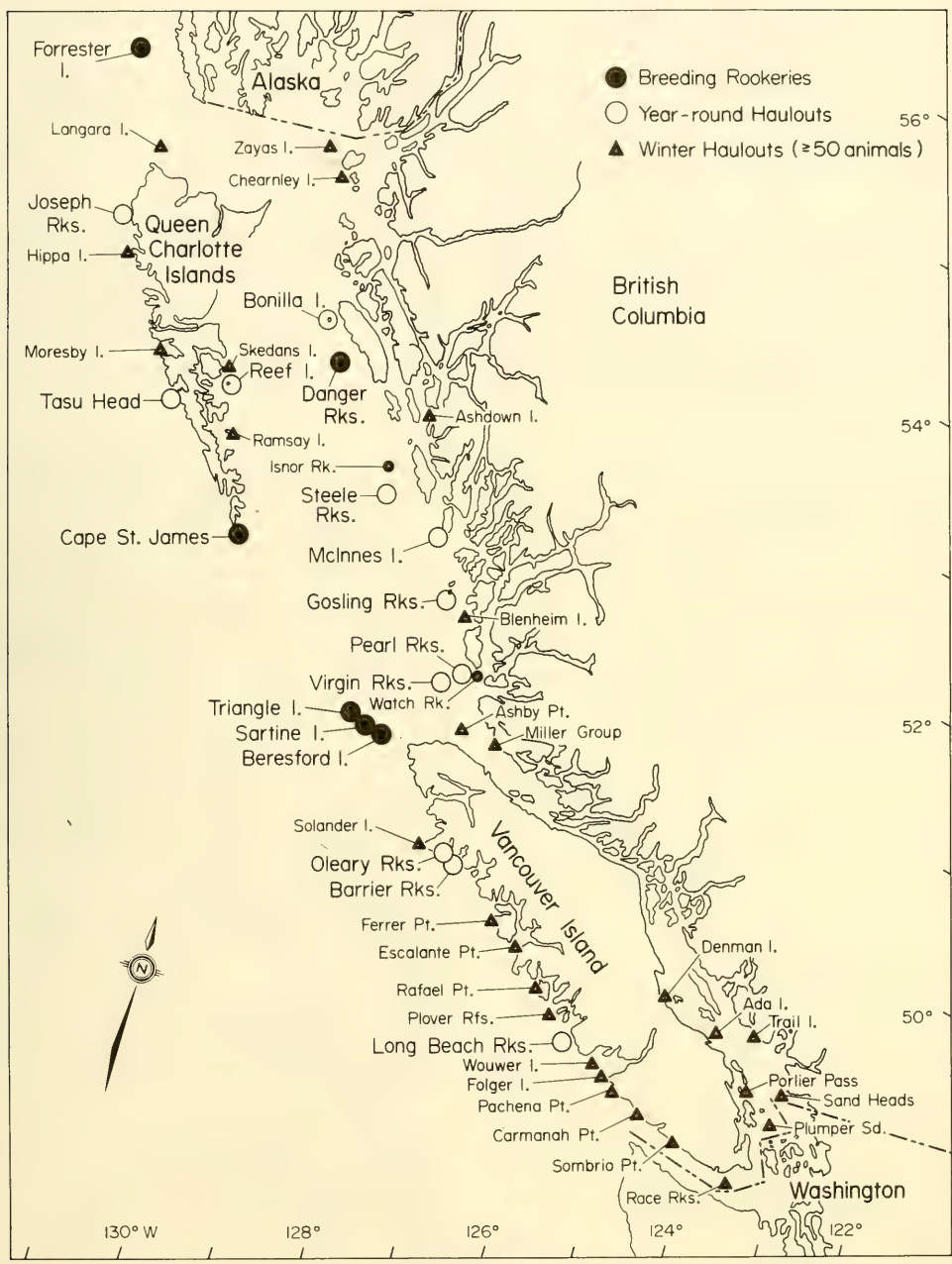


FIGURE 2. Geographical location of current rookeries (●), year-round haulouts (○), and winter sites (▲) of Steller Sea Lions in British Columbia. Only winter sites with ≥ 50 individuals usually present are noted.

and Maxwell (1958) felt that the annual peak in number in British Columbia occurred during early July, and Withrow (1982, *quoted in* Loughlin et al. 1984) suggested it took place during mid-June to

TABLE 1. Percentage of days during each month when Steller Sea Lions were seen on rookeries, year-round haulouts, and exposed winter haulouts in British Columbia during 1956-82.

Site		Month											
		J	F	M	A	M	J	J	A	S	O	N	D
Rookeries	%	100	100	100	100	100	100	100	100	100	—	—	100
	(n)	(6)	(3)	(4)	(10)	(27)	(52)	(20)	(11)	(7)	—	—	(12)
Year-round Haulouts ^a	%	100	100	100	100	95	95	100	85	100	100	100	83
	(n)	(7)	(8)	(8)	(14)	(39)	(91)	(49)	(27)	(11)	(2)	(2)	(23)
Winter Haulouts ^b	%	93	95	86	100	88	26	36	82	75	77	100	96
	(n)	(15)	(22)	(14)	(10)	(9)	(61)	(14)	(17)	(16)	(4)	(6)	(28)

^aFor sites listed in Table 5.
^bFor sites listed in Table 7 except Miller Group, Ashdown Island, sites with less than 50 animals usually present, and sites off southern Vancouver Island between Carmanah Pt. and Denman Island.

mid-July in Alaska. Evermann and Hanna (1925) and Bartholomew and Boolootian (1960) observed that the seasonal timing of births was the same throughout the range. In British Columbia, as elsewhere, births take place from late May to mid-July (Pike and Maxwell 1958; Edie 1977). Figure 3 shows the remarkable similarity in the sequence of pupping on seven rookeries located between California and Alaska. The number of pups born by date was taken from studies by Mathisen et al. (1962), Gentry (1968), Sandegren (1970), Edie

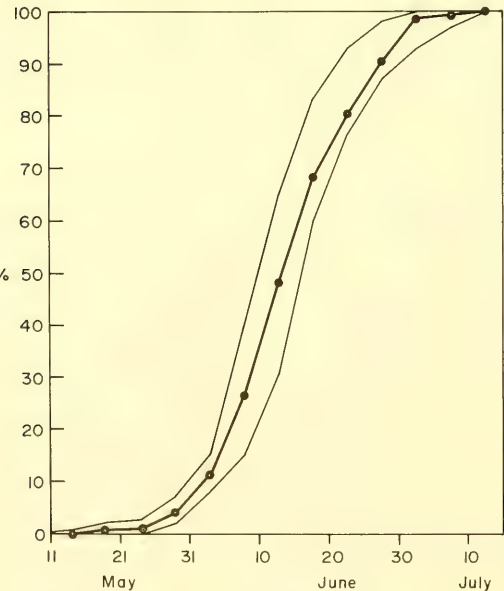


FIGURE 3. The mean and range for the cumulative percentage of Steller Sea Lion pups born, at 5-day intervals, on seven rookeries between California and Alaska.

(1977) and Calkins and Pitcher (1982). On average, 99% of births were completed by July 5.

The total number of animals of all ages seen on rookeries begins to increase at the start of the birth season and to decline after the mating season. The number of bulls reaches a peak in early to mid-June, while the peak for juvenile males is late June, and that for cows and younger females mid- to late June (Gentry 1968; Edie 1977). The number of cows using the rookery must continue to increase until early July, as indicated by the pupping sequence. Presumably, late in the season more cows leave to forage than arrive to pup. Cows give birth within a few days of arrival on the rookery and mate about one to two weeks later (Gentry 1970; Sandegren 1970; Edie 1977). The main time for the departure from the rookery of all individuals, except cows with pups, begins in late July-mid August (Pike and Maxwell 1958; Orr and Poulter 1965; Gentry 1968, 1970; Le Boeuf and Bonnell 1980). Cows with nursing pups cannot leave until the pups learn to swim, in August to September (Orr and Poulter 1967; Sandegren 1970). After July, the number of animals on the rookery declines to a low level by winter and does not increase again until just before the next birth season (Orr and Poulter 1965; Gentry 1968, 1970; Le Boeuf and Bonnell 1980).

Year-round counts were not made at any rookery in British Columbia but the pattern of variation just described was confirmed indirectly. Over the years, counts were made at rookeries during most months, and these data showed changes in the number present by month relative to the number seen in July. Figure 4 indicates that numbers usually decreased to the lowest levels in January-April, then increased in May. Typically, the number present in December was about 25% of

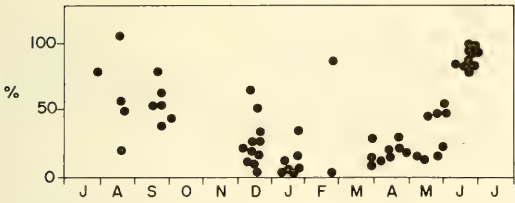


FIGURE 4. Monthly variation in the total number of Steller Sea Lions on rookeries in British Columbia during 1956 to 1982, as indicated by the percentage of total number seen on rookeries in the preceding, or subsequent, July.

that seen in July (Table 2). This review suggests that the largest numbers seen on rookeries in British Columbia, and elsewhere, was usually during July, after pupping but before dispersion.

Not all censuses undertaken during summer in British Columbia were made in July. Some were made in June and August, and hence were not comparable to those in July. One bias that can be corrected is the number of pups yet to be born for those censuses made in June. Figure 3 is used to extrapolate the probable number that would have been born by July 5 for censuses taken after June 20 and the extra pups are added to the total numbers seen. The potential for error in extrapolation increases substantially for censuses undertaken prior to June 20. No correction was made for the number of sea lions that may have been at sea during censuses or for censuses taken in August. The counts made in August would, in general, be lower than if they had been taken in July because movements off rookeries can begin in late July.

The counts on rookeries provide two indices of stock size. The first is the total number of pups and non-pups seen. It gives a minimum estimate of stock size. Additional non-pups may be absent from rookeries due to foraging at sea and to

TABLE 2. Comparison of average number of Steller Sea Lions seen on rookeries, year-round haulouts, and winter sites in British Columbia in summer and winter during 1971 to 1982. Data from Tables 3, 6 and 7.

Site	December 1971-1976	July 1971-1982
Rookeries	960 (15%)	3 872 (65%)
Year-round haulouts	1 527 (24%)	1 919 (32%)
Winter sites	3 812 (61%)	206 (3%)
Total	6 299	5 997

TABLE 3. Total number and number of pups (in parentheses) of Steller Sea Lions seen on rookeries in British Columbia, and on Forrester Island, Alaska, during major summer and winter censuses from 1913 to 1982. Censuses in June that are increased by the additional number expected to be born by early July are indicated by an asterisk.

Year Date	British Columbia							Alaska	
	Triangle I.	Sartine I.	Beresford I.	Virgin Rocks	Pearl Rocks	Watch Rock	N. Danger Rocks	Cape St. James	Forrester I.
Summer									
1913 12/6-28/8 ^a	350 (50)	0	3200(700)	2300(1000)	1410(385)*	103(15)*	1000	2500*(+)	50-100, pre 1929 ^d
1916 22/6-11/7 ^b	(0)	0	6000	2688(1188)*	259 (59)*	3 (0)	1000	1000	350, August 1945 ^e
1938 16-19/8 ^b	1200	2	2000	4000 (0)	12 (2)	(0)	2000	2800	2500, spring 1957 ^f
1956 3/7-1/8 ^h	1750(400)	850(300)	1700(750)	(0)	(0)	(0)	1100(300)	4000(1500)	2396(1096)
1961 20-23/6 ^h	1085(385)	785(385)	935(385)	(26)	(0)	(0)	308(128)	1441 (644)	6187(2400)
1971 28-30/6 ^h	751(201)	809(181)	680(191)	(0)	(0)	(0)	241 (93)	991 (360)	5308(2187), 1981 ^g
1973 29/6-3/7 ^h	580(205)	914(298)	689(204)	(0)	(0)	(0)	440 (93)	821 (272)	5528(2227)
1977 26-30/6 ^h	720(150)	1209(330)	820(168)	(0)	(0)	(0)	300 (70)	1111 (329)	
1982 26/6-1/7 ^h	581(205)	1260(454)	732(190)	(0)	(0)	(0)	268 (80)	1130 (432)	
Winter									
1971 9-12/12 ^c	482	88	87				48	258	963
1976 14-17/12 ^c	369	36	138				104	310	957
									438

Sources: ^aNewcombe and Newcombe (1914); ^bNewcombe et al. (1918); ^cBigg (1985); ^dRowley (1929); ^eImler and Sarber (1947); ^fMathisen and Lopp (1963); ^gLoughlin et al. (1984); ^hPike and Maxwell (1958) and Bigg (1984).

dispersal to year-round haulouts in British Columbia and elsewhere along the coast of the eastern North Pacific Ocean. The second index is the number of pups born and is related to the first. This is the best index of stock size because the total size of the population can be estimated using life table statistics. Unfortunately, the number of pups born was not always separated from the total number seen in early studies. Also, estimates of the number of pups born can be biased by annual differences in natural mortality during the birth season and by the timing of surveys. Storms sometimes kill large numbers (Pike and Maxwell 1958; Orr and Poulter 1967; Edie 1977).

In British Columbia, eight rookeries are known to have existed during this century (Table 3). The rookeries of Triangle Island, Sartine Island, and Beresford Island are sometimes collectively referred to as the Scott Islands, and those of the Virgin Rocks, Pearl Rocks, and Watch Rock as the Sea Otter Group. During 1913 to 1982, nine major censuses were undertaken in summer, and two in winter. Rookeries other than those mentioned by Pike and Maxwell (1958) were not found (Bigg 1985).

Before beginning an interpretation of data on the number of sea lions on rookeries, consideration must be given to the effect that the culling operations may have had on the behaviour of sea lions. These culls for control purposes took place mainly on rookeries (Table 4). Culling operations during censuses could have driven some non-pups away from rookeries and perhaps to other sites. An examination of the timing of culls and censuses indicates that some counts were not affected by culling operations. For example, no culls took place on rookeries during censuses in 1916 and 1971 to 1982. Culling was unlikely to have been a factor in 1956 when only a few individuals were killed on the Scott Islands before the census. Culling may have altered the distribution of sea lions before censuses were made on certain rookeries during 1913, 1938 and 1961. In these instances, individuals could have been driven from the rookery, and then either remained at sea or gone to other haulouts. In the first case, counts would be too low on the site of disturbance, while in the second, the count would be inflated on the site to which animals were driven. However, Pike and Maxwell (1958) felt that animals frightened off rookeries during kills tended to remain swimming nearby in rafts, and hence would still be counted at the site of disturbance. Certainly the annual kills on the Sea Otter Group during 1922 to 1939 (Table 4) did not discourage sea lions from returning each

year. Peterson (1968) noted that, in one instance, tagging operations made in late July on Año Nuevo Island, California, drove animals away for only two days. In another instance, most animals did not return even after a month. Thus, the response to disturbance could vary.

The possibility cannot be ignored that persistent harassment at a rookery during the summer temporarily drove some animals to nearby rookeries, particularly between rookeries within the Scott Islands, or within the Sea Otter Group. Evidence will be presented later that suggests animals were occasionally driven between rookeries of the Scott Islands. However, no evidence exists to indicate that animals were driven between more distant rookeries, such as between the Scott Islands, Sea Otter Group, Cape St. James, and North Danger Rocks, or between rookeries and non-breeding sites. Only on rare occasions during the 1950s and 1960s were a few pregnant females apparently driven from kills on rookeries to pup on the abandoned rookeries of the Sea Otter Group. No pupping was observed on other non-breeding sites during the control programs. Presumably a homing tendency was a powerful force to keep animals returning to their rookery of birth. This being the case, the control kills during 1913, 1938 and 1961 may have caused only local changes in distribution. In 1913, culls took place before the census only on the Scott Islands. In 1938, this happened only on the Scott Islands and Sea Otter Group, and in 1961, only on Cape St. James (Bigg 1984). Counts on the other rookeries during those years were probably not influenced by culling operations elsewhere.

Numbers Seen and Killed on Rookeries: The following account examines the history of numbers seen and killed on each rookery. Emphasis is placed on the evidence used to establish which censuses were the least biased by culling operations or by date of census.

Triangle Island: Triangle Island was apparently a large rookery prior to 1913, but beginning in 1909, sea lions were shot or driven away during the construction and servicing of a lighthouse on the island (Newcombe and Newcombe 1914; Pike and Maxwell 1958). Pupping is thought to have ceased between 1913 and 1916. The rookery probably re-established itself within a few years, because the lighthouse was abandoned by 1920, and many animals were present by 1938. No control programs were directed there prior to 1949. A cull during 1958-1966 resulted in reduced numbers present by 1971 to 1982 (Table 3).

TABLE 4. Total number of Steller Sea Lions reported killed in British Columbia on rookeries and non-rookeries during 1912 to 1968. Number of pups included in parentheses.

Year	Rookery						Non-rookeries	Total
	Triangle Island	Sartine Island	Beresford Island	Virgin Rocks	Pearl Rocks	Cape St. James	N. Danger Rocks	
1912			500 (+)	22 (15)	105 (81)		2000	2000
1913				750				627 (96)
1914								750 ^a
1915			2290+(800+)	----- 1556+	-----		242	4088+(800+) ^{ab}
1922					220 (0)			220 (0)
1923				1760 (649)	125 (5)			1885 (654)
1924				2236 (903)	470(312)			2706 (1215)
1925				2587(1067)	240(102)			2827 (1169)
1926				1442 (565)	514(146)			1956 (711)
1927				1493 (635)	170 (40)			1663 (675)
1928				1007 (375)	32 (2)		103	1142 (377)
1929				1217 (522)	126 (7)		16	1359 (529)
1930				1008 (568)	60 (24)			1068 (592)
1931				1286 (523)	71 (12)			1357 (535)
1932				----- 1128	-----			1128
1933				813 (212)	110 (1)			923 (213)
1934				614 (125)	172 (0)			786 (125)
1935				602 (110)	21 (0)			623 (110)
1936			3529 (1043)	167 (73)	111 (2)		60	3867 (1118)
1937			2061 (428)	157 (62)	24 (0)		343	2585 (490)
1938		867(513)	1207 (535)	25 (4)	29 (2)		122	3252 (1054)
1939			821 (815)	139 (34)	13 (0)		272	1245 (449)
1940							59	134 (0)
1941							111	111
1942							208	208
1943							45	45
1944							97	97
1945							293	293
1946							304	304
1947						12	263	275
1948							113	113
1949		26	35			50	227	364
1950		----- 1878(220) -----					232	2110 (220)
1951							231	231
1952						50 (0)	202	252 (0)
1953	95 (0)						216	311 (0)

(Continued next page)

TABLE 4. (Continued).

Year	Triangle Island	Sartine Island	Beresford Island	Rookery Virgin Rocks	Pearl Rocks	Cape St. James	N. Danger Rocks	Non-rookeries	Total
1954		33 (0)				35 (0)	6	106	180 (6)
1955								176	176
1956		165(117)						134	299 (117)
1957								521	521
1958	25	6	6					689	1103 (158)
1959	1107(471)	64 (0)	1077 (401)			352(145)	377(158)	677	3388 (1050)
1960	111 (0)	14 (0)	59 (0)			1438 (0)	111 (33)	310	2053 (62)
1961	35 (0)	38 (5)	35 (0)			543 (0)	121 (62)	165	816 (5)
1962	23 (0)		49 (0)			480 (0)	193 (80)	638	1383 (80)
1963	117 (0)	24	117 (0)			150 (0)	66 (1)	563	1037 (1)
1964	139 (0)	157 (0)	324 (50)			254 (23)		103	977 (73)
1965		309(246)				169(110)			478 (356)
1966	43 (0)	25 (0)	64 (0)			44 (0)	15	51	227 (0)
1967								55	70
1968								15	15

^aUp to 75% may have been pups.
^b1063+ were killed on the Virgin Rocks, and hundreds were killed on Pearl Rocks.

Sartine Island: This was not a rookery early in the century. No animals were seen there in the censuses of 1913 and 1916. Newcombe and Newcombe (1914) interviewed local Indians familiar with the area who indicated that Sartine Island was not a rookery, whereas Triangle and Beresford islands were. Still, Pike and Maxwell (1958) suggested that Sartine Island was a rookery, but was missed during the censuses. It was a rookery on 13 June 1938, when 513 pups were reportedly killed (Bigg 1984), although only two animals were present by August 1938. But pup counts on Sartine Island during control programs must be interpreted with caution. Culls on the nearby rookeries of Beresford and Triangle islands, to the east and west, sometimes apparently caused animals to be driven to it. In the most extreme example of this bias, G. Pike recorded 800 pups on Sartine Island by 14 June 1960. Had this number represented the natural arrival of cows, then 1500 pups would have been born by early July. This was a number far in excess of that found on the rookery in other years. Pike, in his 1960 field notes, suggested that the unusually large numbers of pups probably resulted from culling operations on Beresford Island and Triangle Island, which drove pregnant females to Sartine Island. Thus, extrapolating for the number of pups that were likely to have been born by the end of the birth season would, in this case, result in an unrealistically large number. A large cull occurred on Beresford Island earlier in June 1938, and so some of the 513 pups killed on Sartine Island may have been born to cows driven from Beresford Island. Perhaps the rookery on Sartine Island formed as a result of animals being driven from the large kills on Beresford Island during 1913 to 1938.

During the period 1959 to 1961, Sartine Island was designated a research area with management and commercial kills forbidden. Nonetheless, small kills for research, management, and commercial purposes still continued from 1959 to 1967. The production of pups changed little between 1956 and 1971 to 1982. With only small kills on Sartine Island, few animals were probably driven from it to Beresford Island and Triangle Island. No other obvious cases exist where pregnant cows were driven between rookeries in British Columbia.

Beresford Island: Of the counts made on Beresford Island in 1913 and 1916, that in 1916 was probably the most representative of the maximum numbers present in July. The count in 1913 was made late in the season (18 August) after a commercial kill of 500 animals. The count in 1916

was made close to the optimum time (27 June), and was not preceded by a kill. Pike and Maxwell (1958) felt that the 1916 count may have been exaggerated, yet Newcombe et al. (1918) stated that "The lowest estimate made as to the number (on Beresford Island) was 6 000". A somewhat higher number may have existed in 1913. During 1913 to 1915, a reported 2 800 animals were killed, although up to 75% of these may have been pups (Newcombe et al. 1918). The count in 1938 was made late in the season, and followed kills reported to total 6 800 sea lions (including 2 000 pups) in the period 1936 to 1938. In 1950, 1 900 sea lions were noted as killed on the Scott Islands. As most kills during these early days were made on Beresford Island, such may have been the case in 1950. By 1956, the population had declined. Large kills followed from 1956 to 1967, which resulted in even smaller numbers by 1971 to 1982. Over the years, killing eliminated pupping at one site. Up to 1966, pups were born on the main island and a large rock to the north (Maggot Island), but during 1971 to 1982, they were born only on the northern rock.

Virgin Rocks: Of the counts made on the Virgin Rocks in 1913 and 1916, that in 1916 probably best indicated the magnitude of numbers present in July. The count in 1913 was made late in the season (28 August), while in 1916 it was made on 25 June. The number present in 1913 was probably somewhat higher than in 1916 in that more than 2 000 animals were reported killed here during the 1914-1915 season, although many were reported to be pups. An intensive annual cull was undertaken during the years 1923 to 1939, and pupping progressively decreased to low levels by 1939 (Table 4). An unusually large number of non-pups was counted in August 1938. These animals must have originated elsewhere, because the population on the rookery was almost eliminated by this time. Field reports of fishery officers in 1938 suggested that the sea lions came from the Scott Islands. The large number of animals seen on the Virgin Rocks could have been part of the postbreeding season dispersal from the Scott Islands, or could have been driven from kills there. Pupping has occurred rarely since, and the Virgin Rocks are used now as a year-round haulout.

Pearl Rocks: The counts in 1913 and 1916 were made fairly close to the optimum time, on 22 June and 25 June, respectively. But the numbers seen decreased sharply between 1913 and 1916, no doubt due to control culls. The magnitude of the culls is unknown, but early records indicate that hundreds of animals were killed on the Sea Otter Group without the exact rookery being noted. The

census in 1913 appears to be the best indicator of the maximum numbers present. An intensive annual cull occurred during 1922 to 1939 and gradually eliminated pupping by the 1930s (Table 4). Pupping has not occurred since, and the site is now used as a year-round haulout.

Watch Rock: This site was noted as a rookery only on 22 June 1913. It was probably eliminated during the culls on the Sea Otter Group of 1913 to 1915. No pups have been found here since, and the site is now abandoned.

Cape St. James: Of the counts made in 1913 and 1916, that in 1913 was probably most indicative of the numbers present in July. A total number of 2 000 was noted on 13 June, 1913 (Newcombe and Newcombe 1914). This count was made early in the season, and so underestimated the number of pups and non-pups that would have been present in early July. Newcombe et al. (1918) suggested adding 500 to this number to account for pups not yet born. The additional number was probably reasonable, although more appropriate for the total increase in number of pups and non-pups present by early July, rather than just for the number of pups. While an extrapolation for the total number present in July, based on counts made so early in the pupping season is prone to error, the importance of an estimate of numbers present in July 1913 makes some speculation necessary. Using daily counts made by Gentry (1968, 1970) on the rookery at Ano Nuevo Island, California, total numbers probably increased by about 25% between 12 June and 5 July, or about 500. Only 1 000 sea lions in all were seen on 13 July 1916. No indication was given as to whether these consisted mainly of pups or non-pups. The reason for the decline between 1913 and 1916 is not clear. No control kills were directed there during this time. Newcombe et al. (1918) felt the decline was due to natural variability in the number of animals hauled out each year. Yet, large variations were not observed during 1971 to 1982 (Table 3). The decline was probably due to harassment prior to the census in 1916 from personnel and servicing vessels for a lighthouse that was erected near the rookery after the census in 1913, and completed by early 1914.

A count late in the season during 1938 noted 2 800 present, and an increase in numbers occurred by 1956. No culls were reported on the rookery up to this time. Large culls during 1959 to 1967 sharply reduced numbers between 1957 and 1971 to 1982. With a commercial kill of about 500 adults preceding the count in 1961 (Bigg 1984), some non-pups may have been driven from the rookery

resulting in an underestimate for the number of animals reported there in 1961.

North Danger Rocks: This small rookery was not censused in 1913 or 1916. But Newcombe and Newcombe (1914) interviewed Indians who indicated that it was a rookery containing perhaps 1 000 sea lions. Essentially no culls occurred there between 1913 and 1957. In 1958 to 1967 a relatively large cull was conducted, resulting in a decline in numbers between 1956 and 1971 to 1982.

Forrester Island: The rookeries off northern Forrester Island, Alaska (Figure 2) are important to consider in this study because of their proximity, and their possible effect on the growth of stocks in British Columbia. These rookeries may have formed in the 1910s or 1920s and have increased remarkably in size. Rowley (1929) mentioned, without giving a date, that a rookery existed there with only 50 to 100 individuals. Since then the population has steadily increased, and stabilized during 1973 to 1982 (Table 3). Between 1961 and 1973, the production of pups increased at an average rate of 6.8% annually. The only killing reported was 190 sea lions in 1960 (Bigg 1984). While control programs resulted in decreased numbers of animals on most rookeries in British Columbia, the lack of culls at Forrester Island allowed these rookeries to increase in size.

Effect of Kills on Pup Production: A crude estimate of the relationship between the number of sea lions reported to have been killed in British Columbia, and the decline in the population during 1956 to 1968 can be determined from the data given in Table 3 and Table 4. In all, 8 446 animals were killed on rookeries (1956 to 1968), and 3 921 on non-breeding sites. About 15% of the kill consisted of pups. This proportion would be higher if one assumed that the killing of nursing cows on rookeries also resulted in the death of pups through starvation. Still, the kill was directed mainly at non-pups, and the kill of pups was probably not important to the overall reduction in the size of the breeding stock. A high natural mortality is experienced during the first year of life (Calkins and Pitcher 1982). The decline in the total population between 1956 and 1968 is not known with certainty, although the number of pups born between 1956 and 1971 decreased by 2 224. With little change in the number of pups born during 1971 to 1977, a reasonable assumption is that the numbers of pups present in 1968 was of a similar magnitude. For all the rookeries in British Columbia combined, an average of 2.9 non-pups were killed for each pup reduced. For the Scott Islands, the ratio was 3.2:1; for Cape St. James it

was 2.8:1, and for North Danger Rocks it was 2.7:1.

The kill at non-breeding sites no doubt also contributed to the decline in the production of pups on rookeries in British Columbia. Essentially all of these kills were non-pups. Combining the kill at all non-breeding sites, an average of 1.8 non-pups were killed per pup reduced on rookeries. Unfortunately, the rookery of origin for those killed at non-breeding sites was not known. Data presented later suggest most animals on winter haulouts originate from rookeries in British Columbia, with some sea lions originating from rookeries in California, Oregon and possibly Alaska. At present, the kill at non-breeding sites cannot be apportioned to any particular rookeries. Hence, with some animals probably originating from rookeries outside of British Columbia, the ratio would be less than 1.8:1 for stocks originating in British Columbia.

Assuming that the age and sex composition of animals present in British Columbia during the year was not biased for a self-reproducing population, the kill of non-pups may well have been close to random. Killing took place wherever animals were seen during the year, at rookeries, year-round haulouts, winter haulouts, and rafting areas. The kill for commercial purposes was directed mainly at adult males and cows on rookeries during summer, while the kill for management purposes tended to be random, and was directed at both rookeries and non-breeding sites in summer and winter. The kill for research purposes was relatively small, and tended not to be selective. It took place mainly in summer at rookeries and non-breeding sites. The life tables for this species derived by Calkins and Pitcher (1982) indicate that 3.5 non-pups exist per pup in a self-sustaining population. The ratio of the number of non-pups killed per pup reduced in British Columbia during 1956 to 1968 may have been close to this theoretical ratio. Although the combined ratios from kills on rookeries and non-rookeries in British Columbia was higher, 4.7:1, it was also biased. The number of non-pups reported killed for management purposes was inflated, and not all non-pups killed on non-breeding sites were likely to have been born on rookeries in British Columbia.

Numbers on Year-Round Haulouts: All year-round sites used by Steller Sea Lions in British Columbia since 1956 were probably located during the extensive coastal surveys by vessels and aircraft for sea lions. Table 5 shows that of the 15 sites known during 1956 to 1982, only 12 were used

TABLE 5. The year-round haulouts in British Columbia, numbers of Steller Sea Lions seen on them during 1956-1982, and history of site use.

Haulout	June-August			September-May			History	
	$\bar{x}$	Max	n	$\bar{x}$	Max	n	First Noted	Changes in Use
Long Beach Rocks	134	394	27	132	350	22	1913	
Barrier Rocks	115	250	7	155	398	4	1955	
O'Leary Rocks	155	331	15	162	305	14	1955	
Solander Island	156	350	7	85	200	8	1913	Winter site since mid-1960s
Virgin Rocks	256	800	16	177	370	11	1913	Rookery up to 1930s
Pearl Rocks	100	276	16	104	300	11	1913	Rookery up to 1930s
Gosling Rocks	59	179	8	82	223	9	1956	
McInnes Island ^a	70	196	12	74	150	8	1938	
Steele Rocks	88	150	3	157	183	2	1971	Newly formed
Isnor Rock	142	250	5	78	160	3	1913	Abandoned since mid-1960s
Bonilla Island	144	350	10	93	144	4	1913	
Reef Island	148	300	14	149	600	9	1956	
South Tasu	105	278	5	76	200	5	1940s	
Joseph Rocks	278	408	14	390	500	2	1930	
Langara Island	136	450	8	187	350	2	1937	Winter site since mid-1960s

^aExcludes data in Figure 5.

since the mid-1960s. Pike and Maxwell (1958) noted all of the sites listed, except for Long Beach Rocks, Barrier Rocks, O'Leary Rocks and Steele Rocks. Solander Island and Langara Island, have not been used regularly in summer since the mid-1960s, and may now be used only as winter haulouts. Steele Rock appears to have replaced nearby Isnor Rock as a year-round haulout.

The year-round haulouts were used by sea lions over many years, in some cases extending back to 1913. Information for other sites extends back only

to the 1930s to the 1950s due to the absence of early records about any sites other than rookeries. All year-round sites were subjected to repeated kills over the years. Yet sea lions returned, presumably because each site had some long-term attraction, such as for food, security, or tradition.

The number seen on each year-round haulout during 1956 to 1982 was typically 50 to 250 animals throughout the year, depending on the site (Table 5). The numbers present do not appear to vary much between summer and winter (Table 6). Similarly, Figure 5 shows the maximum number seen each month on McInnes Island during 1963 to 1964 did not vary markedly through the year. Unfortunately, the records for daily counts at this site were lost. Harestad (1977) recorded the number of sea lions seen on McInnes Island during 1972 to 1973, but noted a peak in mean numbers of 100 animals during June, and a decrease to a mean of less than 25 for most other months.

Pike and Maxwell (1958) felt that considerable annual and seasonal variation occurred in number of animals on non-breeding sites. An inspection of the data used to derive Table 5 (see Bigg 1984) confirms that daily numbers were quite variable. However, the variability was, at least in part, due to temporary departures of animals from the sites, caused perhaps by storms or harassment. Our aerial surveys (Bigg 1985) indicated that a search in the vicinity of sites where no animals, or only a few animals, were hauled out often found the sea lions swimming in rafts nearby. Thus, animals tended to

TABLE 6. Total number of Steller Sea Lions seen and estimated at year-round haulouts for major censuses made during summer and winter 1957 to 1982. Number of sites missed in parentheses.

Year	Date	Seen	Missed*	Total
Summer				
1957	27/6-17/8	2 097	0	2 097
1961	20-23/6	1 350	354 (3)	1 704
1964	8-11/6	1 249	308 (3)	1 557
1971	28-30/6	2 170	203 (2)	2 373
1977	27/6-2/7	2 003	0	2 003
1982	28-30/6	1 781	0	1 781
Winter				
1971	7-12/12	1 021	545 (2)	1 566
1976	13-21/12	1 489	0	1 489

*The average number given in Table 5 is used for sites missed.

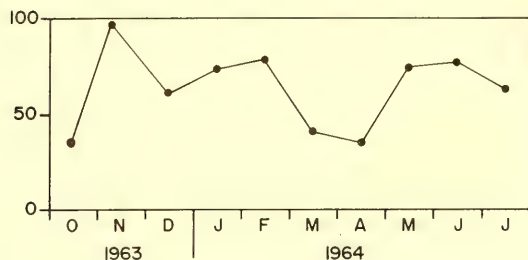


FIGURE 5. Maximum number of Steller Sea Lions seen each month on McInnes Island by lighthouse keepers during 1963 to 1964.

remain in the area, although were not always hauled out at the year-round site. In this regard, the mean number hauled out per month is not a particularly good indicator of the number of sea lions using the site. Frequent temporary departures can severely bias the mean number as an indicator of site importance. The maximum number seen per month is a more useful statistic. Figure 6 illustrates this point for an exposed winter haulout.

The total number seen at all year-round sites in summer remained relatively stable between 1957 and 1982, averaging about 1 900 animals (Table 6). That the number of sea lions did not decrease during this time, as found on rookeries, is surprising. The reason may be that the numbers seen on year-round haulouts are not a simple proportion of the numbers on rookeries. An example in which little correlation existed between an increase in numbers on a rookery and the increase in numbers on a nearby year-round haulout was Forrester Island and Joseph Rocks. Joseph Rocks is a large year-round haulout that can physically accommodate many more individuals than it does currently. A 75-fold increase in the number of animals took place on the rookeries of Forrester Island between the 1930s and 1973 to 1982 (Table 3). Yet, only a two-fold increase was seen on Joseph Rocks during the same period (Bigg 1984). Perhaps local food supply limited the number of sea lions that could be supported at a year-round haulout. Emigration could have taken place. Another possibility was that the numbers seen during the 1950s were biased due to harassment prior to censuses. Also, the number of animals on year-round haulouts could have been reduced for sea lions born on rookeries in British Columbia, but their reduction was masked by an influx of animals from Forrester Island.

Numbers on Winter Haulouts and Rafting Sites: A total of 24 sites on which more than 50 Steller Sea Lions usually hauled out in winter (but, generally deserted in summer) were found in British Columbia (Table 7). At least 25 additional winter sites existed at which smaller numbers of sea lions were seen hauled out or rafting (Bigg 1984). These latter sites were found mainly in exposed areas. Little information is available on the historical use of most winter sites, although some were used back to 1913. Most of the effort to census animals at winter sites during 1971 to 1982 was directed at those in exposed coastal areas. The censuses of winter sites during summer probably recorded essentially all animals hauled out or rafting in British Columbia, as the species was not commonly found in sheltered areas at that time. However, censuses of winter sites during winter probably missed small groups of animals located in sheltered inlets and channels. The species appears to disperse widely in exposed and sheltered areas during winter. Censuses during winter in sheltered areas were made only at sites known or suspected to have sea lions present, and hence much of the sheltered coastline was not examined. Still, regional coverage by others was extensive (Bigg 1984) and it is unlikely that important sites were missed.

The first significant arrivals to winter haulouts in exposed locations were seen during August (Table 1). These animals could have come from rookeries or year-round haulouts. Sites in sheltered areas were probably not occupied until later. This was the case for sites off southern Vancouver Island where arrival times were progressively later eastward, and more distant from summer sites. Daily counts at three sites illustrate the pattern. At Pachena Point, the species arrived in large numbers during September, and was seen frequently through until April (Figure 6). Animals were rarely seen during May–August. The numbers hauled out during winter were quite variable, apparently because storms caused ocean swells to swamp the haulout, and to drive sea lions into the ocean. At Race Rocks, during 1971, only a few animals began to arrive by September (Figure 7). Numbers reached a peak in January to March. Too few counts were made in December to be sure of the numbers present in that month. Departures were completed by late May. Records of the numbers seen each day were kept during other years between 1965 and 1979. While these records were not as complete as those for 1971, they nonetheless showed the same pattern of arrival and departure (Bigg 1984). At the

TABLE 7. The winter haulouts in British Columbia, numbers of Steller Sea Lions seen on them during summer and winter 1971-1982, and history of site use. Only sites where 50 animals were seen regularly are listed individually. Numbers in parentheses were assumed from the subsequent or preceding count.

Haulout	Winter		Summer		History	
	1971	1976	1977	1982	First	Changes in use
	7-12/12	13-21/12	27/6-2/7	28-30/6	Noted	
Race Rocks	35	113	0	(0)	1965	Newly formed
Ada Island	0	131	0	(0)	1973	Newly formed
Trail Island	0	91	0	(0)	1973	Newly formed
Miller Group	210	307	0	0	1971	
Ashby Pt.	(31)	31	4	1	1915	
Sombrio Pt.	16	1	0	0	1970	
Carmanah Pt.	0	124	181	170	1938	
Pachena Pt.	24	1	0	0	1970	
Folger Island	284	23	0	0	1955	
Wouwer Island	116	61	0	0	1958	
Plover Reefs	215	185	1	0	1969	
Raphael Pt.	0	36	0	0	1938	
Escalante Pt.	(85)	85	0	0	1955	
Ferrer Pt.	124	217	1	0	1954	
Solander Island	71	34	1	0		See Table 5
Blenheim Island	(65)	65	0	0	1913	
Ashdown Island	(119)	119	0	(0)	1960	
Chearnley Island	(546)	546	0	0	1913	
Zayas Island	(223)	223	0	0	1913	
Ramsay Island	223	396	0	0	1971	
Skedans Island	414	491	0	45	1956	
Moresby Island	57	96	0	0	1957	
Hippa Island	298	292	0	0	1959	
Langara Island	227	121	0	3		See Table 5
Sites with < 50 animals	230	222	2	4		
Total	3613	4011	189	223		

most inland site, Ada Island, only small numbers arrived by October, most arrived by November, and the largest number occurred generally in March (Figure 8). All sea lions left by late May. Because of an annual increase in numbers, the seasonal variations in numbers seen at this site were calculated using the percentage of the maximum number seen each month relative to the maximum number seen in March of each winter season. The maximum number noted for each month was used for those months when at least five days of observations were made. Ada Island was also occupied by a few California Sea Lions (*Zalophus californianus*). In 11 censuses made during 1975 to 1982, Steller Sea Lions comprised an average of 88% (range 79% to 97%) of the total numbers seen.

A unique local movement schedule for up to at least 60 individuals was recorded during 1978 to 1982 at Sand Heads near the mouth of the Fraser River. Fishery officers and lighthouse keepers

reported that Steller Sea Lions arrived in mid-March, reached a peak in numbers in late April – early May, and left by late May. The species visited the site apparently to feed mainly on Eulachon (*Thaleichthys pacificus*) that spawn in the river at

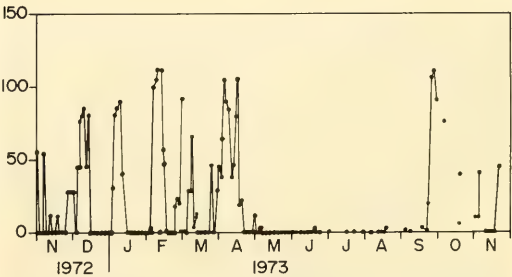


FIGURE 6. Daily number of Steller Sea Lions seen at Pachena Point by lighthouse keepers during 1972 to 1973.

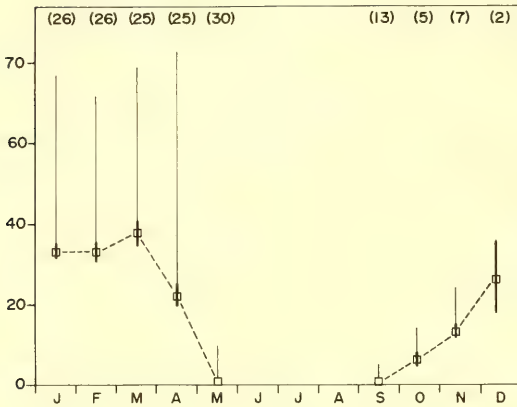


FIGURE 7. Monthly mean, standard error of the mean, and maximum number of Steller Sea Lions seen at Race Rocks by T. Anderson, the light house keeper, during 1971. Number of days observed in parentheses.

this time. Fishery officers also noted that the species entered numerous long inlets throughout the mainland coast of British Columbia during February-April to feed on spawning Pacific Herring (*Clupea harengus pallasii*), and Eulachon (Bigg 1984). Departure from winter sites throughout British Columbia appears to be essentially completed by late May.

Population Trends

British Columbia: The number of Steller Sea Lions in British Columbia apparently increased during the late 1800s and early 1900s. Newcombe et al. (1918) stated that fishermen felt sea lions were more numerous in 1913 than in the late 1800s. This increase may have been caused by a recovery of the population after an earlier depletion by natives for meat, hides, oil and other products (Newcombe and Newcombe 1914; Wailes and Newcombe 1929). The Alaska Department of Fish and Game (1973) reported the species in Alaska was reduced prior to 1900 for the same reason. If natives did deplete the population in British Columbia, then the numbers of sea lions would have been low during the early 1800s, when the number of Indians was relatively high — at about 70 000 (Duff 1977). By 1885, epidemics had reduced the Indian population to only 28 000. Utilization of sea lions also decreased through the 1800s, with few Indians in British Columbia relying on them by the early 1900s. The growing numbers of sea lions resulted in the census in 1913, and the control programs.

The changes in population size in British Columbia after 1913 can be traced using the two indices: total number of pups and non-pups seen on rookeries, and total number of pups born (Table 3). Newcombe and Newcombe (1914) estimated the total number of pups and non-pups seen on rookeries to be about 9 300 in 1913. Newcombe et al. (1918) reported it to be larger, about 9 800 in 1916, despite a control program during the intervening years. The similarity in the results of these two censuses appears to be coincidental. In fact, they were neither comparable in timing, nor in degree of preceding harassment. Counts at Beresford Island, Virgin Rocks, and Cape St. James in 1913 were made before or after maximum numbers were ashore in July. Harassment preceded the counts on Beresford Island in 1913, and probably on Cape St. James in 1916. Based on an examination of the most reliable counts of pups and non-pups on each rookery during 1913 and 1916, the total number of animals seen on rookeries during 1913 as probably closer to 14 000 pups and non-pups. The census in 1913 was best for Triangle Island, Pearl Rocks, Water Rock, and Cape St. James. These sites had a total of about 4 400 animals. The census in 1916 was best for Beresford Island and Virgin Rocks. These had about 8 700 sea lions. The number present on the latter rookeries in 1913 may not have been much larger than in 1916 because, despite the fact that more than 4 600 animals were killed there between 1913 and 1915, up to 75% of kills may have been pups. Also, some annual recruitment of non-pups from non-rookery areas probably took place, and this would replace some of the animals killed. Added to the total number were 1 000 animals probably present on North Danger Rocks.

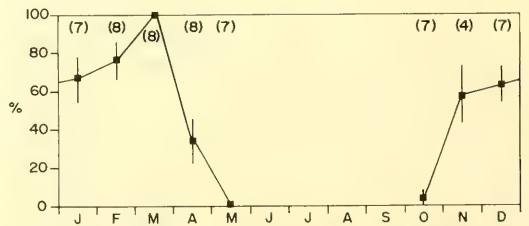


FIGURE 8. Monthly variation in the mean maximum number, and standard error of the mean, of Steller Sea Lions seen at Ada Island by I. MacAskie during 1974 to 1982, expressed as a percentage of the maximum number seen in March of each winter season. Number of years of observation shown in parentheses.

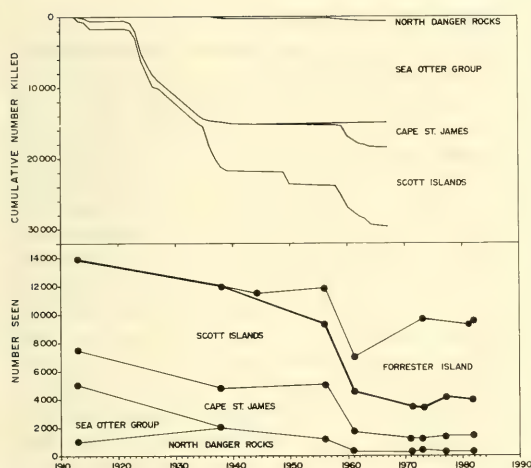


FIGURE 9. Total number of pups and non-pups of Steller Sea Lions seen on rookery groupings in British Columbia, and on Forrester Island, Alaska, during 1913 to 1982, and the cumulative number of non-pups killed in British Columbia. Kills on the Sea Otter Group were assumed to consist of 75% pups. Data from text and Tables 3 and 4.

Alternatively, if one ignored the potential effects of harassment and of seasonal timing of censuses, but incorporated a correction for extra pups born and the likely number on North Danger Rocks, then the population on rookeries numbered at least 11 000 in 1913 (Table 3). The range was thus 11 000–14 000.

By 1938, rookeries of the Sea Otter Group were essentially eliminated through intensive annual kills since 1922 (Figure 9). Countering this decline were increases on the Scott Islands, on Triangle Island and on Sartine Island, although a decrease took place on Beresford Island. Assuming that the 4 000 sea lions seen on the Virgin Rocks in August 1938 originated from the Scott Island, the Scott Island rookeries would have contained about 7 200 animals in 1938. The total number of animals seen in British Columbia during 1938 was similar to that in 1913. However, as the census in 1938 followed reported kills of 7 900 sea lions (2 400 pups) in 1936 to 1938 on the Scott Islands, the rookeries of the Scott Islands must have increased between 1913 and 1936. Thus the total number of animals on rookeries in British Columbia could have increased by several thousand between 1913 and 1936, despite the elimination of most animals on the rookeries of the Sea Otter Group.

No kills for management or commercial purposes took place on rookeries between 1940

and 1956, except for one kill on the Scott Islands in 1950. However, the Canadian airforce and navy apparently made substantial kills during the 1940s. By 1956, the total population seen on rookeries in British Columbia had decreased. The decrease could have resulted from: the elimination of rookeries on the Sea Otter Group where no recovery was possible; the lack of time for recovery by the population on the Scott Islands following the large kills of 1936 to 1939 and 1950; and from kills by military personnel during the 1940s. After 1956, large culls continued on the Scott Islands, North Danger Rocks, and Cape St. James. This resulted in a further decrease in total numbers seen by 1961. Subsequent culls brought still more reductions on all rookery groupings to relatively low, but stable, numbers by 1971 to 1982. Based on the total number of pups and non-pups seen on rookeries, only about 27% to 34% of the population estimated to have been seen in 1913 was present by 1971 to 1982.

Interestingly, the reduction observed on rookeries in British Columbia was matched by, or occurred concurrently with, increases on Forrester Island. The growth of the stock at Forrester Island could have filled the niche vacated by the extinct rookeries at the Sea Otter Group and the reduced size of the remaining rookeries in British Columbia. Such being the case, the population on Forrester Island could be included with the rookeries in British Columbia, as part of a larger regional sea lion population. The total number present in the region during 1971 to 1982 would then be only about 67% to 87% of the level in 1913. The total number of pups and non-pups seen in British Columbia during 1971–1982 compares with the following recent total counts for the species seen elsewhere in the North Pacific Ocean: 28 300 off the USSR; 196 500 off Alaska, 1 000 off Washington, 2 300 off Oregon, and 3 000 off California (Loughlin et al. 1984).

The number of pups born suggests a similar decline to that indicated by the total number of pups and non-pups seen on rookeries. Unfortunately, little attention was paid to the counting of pups in 1913 to 1916, and none in 1938. However, early pup production was likely to be at least as large as that seen in 1956. Thus, by 1971 to 1982, pup production probably declined to 35% or less of that in 1913. If the number of pups currently born on Forrester Island was included with those on rookeries in British Columbia, then the regional stock may have actually increased by 5% since 1956. During 1971–1982, about twice as many pups were born on Forrester Island as on all rookeries combined in British Columbia (Table 3).

A comparison of annual changes in the production of pups in British Columbia during 1971 to 1982 suggests that an increase in breeding stock may have occurred between 1977 and 1982 (Table 3). However, with no increase in the number of non-pups seen during this time, the increase in numbers of pups seen in 1982 may be indicative only of better survival of pups in 1982 than usual, and not a true increase in size of the breeding stock.

Few data exist on the change in numbers that may have taken place at year-round haulouts since 1913. During June-August 1913, Newcombe and Newcombe (1914) visited only Isnor Rock, where 18 sea lions were seen, and Solander Island, where none were seen. Nonetheless, based on conversations with Indians and fishermen, Newcombe and Newcombe (1914) felt that perhaps 1 700 animals were present on non-breeding sites in summer. Later, Newcombe et al. (1918) suggested the number was much larger, as high as 10 000 animals. This figure was not based on direct evidence of more animals seen. It was largely a guess used to explain the lack of an observed decline in the population between 1913 and 1916 and the apparent variability in the number of animals hauled out on Cape St. James in 1913 and 1916. Bigg (1985) suggests that this reasoning was not correct, and hence the number may have been closer to the estimate given for 1913. Insufficient counts were made during summer to indicate whether the number present on year-round haulouts was larger prior to 1956.

The total size of the British Columbia stock can be estimated from the number of pups born. Calkins and Pitcher (1982) calculated the total number of pups and non-pups present at the end of the pupping season in Alaska to average about 4.5 times the number of pups born. Assuming this to be the case in British Columbia, then the stock in 1956 consisted of 14 625 animals. This number was larger than the 11 300 estimated to have been seen on rookeries and year-round haulouts (in 1900) at that time (Tables 3, 6). The extra animals could have been at sea feeding and dispersed to coastal areas outside of British Columbia. Using the same multiple, the mean size of the stock in 1971 to 1982 was 5 100 animals. But this figure was about 600 less than that seen on rookeries and year-round haulouts in summer during these years. The closer correlation between the number observed and expected could reflect an increased accuracy of current censusing methods or an increase in the number of sea lions originating from Forrester Island.

The counts on rookeries during summer 1971 to 1982 in British Columbia indicate a lack of recovery of the population following the end of the

control programs in the mid-1960s. An increase in the number of pups was expected for the depleted rookeries, perhaps at the rate of 7%/year, as found on Forrester Island between 1961 and 1973. Several reasons are possible for the lack of recovery. One may be that the recent large growth of rookeries on nearby Forrester Island inhibited the recovery of stocks in British Columbia. The stocks from British Columbia and Forrester Island probably mix at some time during the year, and thus could compete for food. If this is the case, the population in British Columbia will not exhibit a marked recovery in the future to the levels recorded during 1913 to 1956. The number of pups and non-pups in British Columbia and at Forrester Island indicate that the size of the current regional population may not be much below that seen during 1913 to 1956, and thus perhaps is near the carrying capacity. Another possibility is that no obvious cause for the lack of recovery may be evident. Braham et al. (1980) showed the total number of animals in the eastern Aleutian Islands declined unexplainably from about 50 000 in the late 1950s to about 25 000 in 1977. Shifts in distribution, disease (leptospirosis), and increased commercial fishing were considered. Loughlin et al. (1984) examined trends in numbers of this species throughout its range, and concluded that total numbers did not change between 1956 and 1980. However, these authors suggest that some regional shift in numbers appears to have taken place in Alaska, perhaps due to animal displacement or seasonal movements. Alternatively, Fowler (1982) studied the recent lower than expected productivity of Northern Fur Seals (*Callorhinus ursinus*) in the eastern North Pacific. He showed one likely cause for the decline was an increase in natural mortality due to an increase in the rate of entanglement in synthetic scrap fishnet and plastic packing bands. A minimum of 5% of Northern Fur Seals now die per year from this cause. We have also seen Steller Sea Lions in British Columbia with this kind of debris around their necks. Another obvious possibility is that increased commercial fishing had reduced the food supply for the species, and this resulted in a reduced carrying capacity.

Southeastern Vancouver Island: Censuses during 1972 to 1984 (Table 8) indicate that the number of Steller Sea Lions increased recently during winter off southeastern Vancouver Island, although a decrease has now taken place. Beginning in about 1972-1973, the species increased in numbers throughout southeastern Vancouver Island. This can be illustrated by the occupation of progressively more haulouts. For

TABLE 8. Number of Steller Sea Lions seen off southeastern Vancouver Island during 1972 to 1984.

	1972	1973	1977	1978	1982	1984
	25 Feb.	25 Jan.	7-9 Feb.	9 Feb.	17-22 Feb.	15-16 Feb.
Race Rocks	71	45	68	139	53	22
Plumper Sound area	0	0	286	115	294	23
Porlier Pass area	0	0	0	0	105	112
Ada Island	0	40	211	351	163	139
Denman Island	0	0	0	0	324	0
Other	0	0	0	15	43	32
Total	71	85	565	622	983	328

example, the species was seen regularly for the first time at Ada Island and Trail Islands in 1973, at Plumper Sound in 1977, at Sand Heads in 1978, Denman Island in 1979, and Porlier Pass in 1982. The number of animals increased progressively between 1972 and 1982. The trend of increasing numbers during the 1970s was also indicated from daily counts at two haulouts. Some animals at these sites were hidden from view, and so the numbers given are indicative mainly of trends rather than absolute numbers. Sea lions were not seen at Race Rocks up to the early 1960s (Figure 10). A few animals were present by the mid-1960s, and numbers increased through to 1978, reaching a peak of 250 animals. At Ada Island, numbers increased up to 1978, reached a peak of about 400 animals, and remained at fairly stable level up to 1982 (Figure 11). However, between 1982 and 1984 a sharp decline took place off southeastern Vancouver Island with the main decreases at Denman Island and Plumper Sound (Table 8).

The yearly changes in numbers of animals seen off southeastern Vancouver Island were likely due to shifts in the distribution of wintering animals. The changes did not mirror variations in the size of the populations at rookeries in British Columbia, at Forrester Island, or at rookeries off Oregon and

California (Le Boeuf and Bonnel 1980; Loughlin et al. 1984). The increase in numbers during 1972 to 1982 could have been caused by an increase in local food supply. Studies of diet from an examination of scats indicate that herring is the most important prey for Steller Sea Lions off southeastern Vancouver Island (P. Olesiuk, Department of Fisheries and Oceans, Pacific Biological Station, Nanaimo, British Columbia; personal communication). This sea lion is also reported to feed extensively on herring during winter in sheltered areas elsewhere in British Columbia (Newcombe et al. 1918; Spalding 1964). Stocks of herring off southeastern Vancouver Island were severely depleted by over-fishing during the late 1960s, but recovered by the mid-1970s (Hourston 1980). An alternate explanation, or at least a contributing factor, for an increase during 1972 to 1982, may be that the control programs kept many animals away up to the late 1960s. The species was frequently hunted in this populated region. With protection in 1970, harassment ceased and sea lions could have returned. Certainly the species now hauls out at many sites where they were not known to do so previously during this century, such as at Ada Island, Trail Islands, Sand Heads and Race Rocks.

The main decreases in the number of Steller Sea Lions off southeastern Vancouver Island between 1982 and 1984 were at sites that were important spawning grounds for herring. Relatively few herring were present at Denman Island and Plumper Sound during February 1984 (Armstrong, personal communication). The lack of food may have driven the animals elsewhere. As the number at other sites off southeastern Vancouver Island did not change, animals must have been displaced outside this region. Another possible reason for the decrease is that Steller Sea Lions experienced increased competition for food from California Sea Lions. California Sea Lions recently increased off southeastern Vancouver

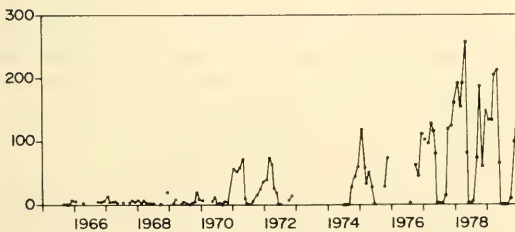


FIGURE 10. Monthly maximum number of Steller Sea Lions seen at Race Rocks during 1965 to 1979 as recorded by T. Anderson, the light house keeper.

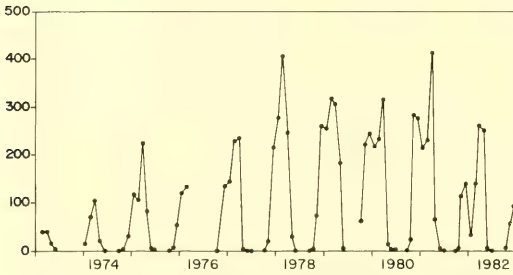


FIGURE 11. Monthly maximum number of Steller Sea Lions seen at Ada Island by I. MacAskie during 1973 to 1982.

Island during winter from about 50 in 1972 to about 1 700 by 1984. In either case, the current size of the Steller Sea Lion population there is probably closer to that prior to the 1970s, based on the few earlier sighting records available (Bigg 1984), than that seen in 1982.

Habitat

Steller Sea Lions in British Columbia congregate at four kinds of sites:

1. *Rookeries*. These sites are located farthest from land masses, and are the most exposed to oceanic swells. Essentially all births and breeding takes place there. Some animals are usually present throughout the year (Table 2), with the largest number seen in July. In summer, rookery populations are composed of cows, pups, bulls, and juvenile males and females (Orr and Poulter 1965; Gentry 1968, 1970; Edie 1977). In winter, they are mainly cows with young-of-the-year.

2. *Year-round haulouts*. These are usually found in locations that are exposed directly to oceanic swells, but unlike rookeries, are located close to land masses. Births and matings rarely take place there (Harestad and Fisher 1975). Animals are present year-round, with no marked seasonal variation in numbers seen. The presence of animals during June to July is particularly characteristic. The population composition in summer appears to consist of either young bulls or a mixture of ages and sexes (Pike and Maxwell 1958; Harestad and Fisher 1975). In winter, bulls and cows with young-of-the-year are present, along with other animals of unknown age and sex.

3. *Winter haulouts*. These are found in exposed locations, similar to those of year-round haulouts, and in sheltered inlets and channels. Sites in exposed locations generally are not open directly to oceanic swells but rather are sheltered to some

extent by the surrounding topography (e.g. within a bay; on the leeward side of an island). These sites tend to be smaller than the other kinds of haulouts. The main period of occupancy is winter although sea lions can be present sometimes from August to May. Occupancy can be continuous or intermittent. Sites where less than about 50 animals hauled out are used least frequently. The absence of animals, or the presence of only a few individuals during June to July is characteristic. Occasionally winter sites located in exposed areas appear to be used in June to July by animals normally present on nearby year-round haulouts. Some winter sites in sheltered waters contain only adult and sub-adult males. Exposed sites generally have bulls and cows with young-of-the-year, plus other individuals of unknown age and sex.

4. *Winter rafting sites*. Where no suitable haulout site is available, sea lions rest on the water surface in a tightly packed group, or raft. Rafting sites are found mainly close to shore in sheltered inlets and channels, but exist sometimes in exposed localities. The exact location of rafts may change by several miles during the year, perhaps in response to changes in the location of the food supply. Rafts are most commonly seen in winter, but may be present from fall to spring. The age and sex composition of animals at these sites is not known.

General Biology

Reproduction and Behaviour: During the breeding season, mature bulls establish stable territories with defined boundaries (Gentry 1970; Sandegren 1970) which are maintained by threat displays. The territories are maintained throughout the breeding areas which may be as long as 68 days (Gentry 1970). Bulls do not usually feed during this period. The same site may be held in successive years and the sites are usually selected before the female population peaks but are usually associated with areas of female concentrations (Gentry 1970).

Females have been observed to compete *pro partum* for favoured birthing sites and become very aggressive prior to parturition to provide a clear area for birth (Gentry 1970; Sandegren 1970). The females stay with the pup from 5 to 13 days before going to the sea to feed and from then on return to the sea at regular intervals, leaving the pups to collect in "pods" (Schusterman 1981). Females will accept only their own pup which is probably recognized by smell (Ono 1972). Pups continue to nurse until at least September, and some continue for one year (Gentry 1968, 1970).

Copulation takes place on land or in shallow tidal pools 11-12 days *post partum* (Gentry 1970; Sandegren 1970) with a gestation period of 11 months (Harrison 1969). Lactation may last for a year or more (Schusterman 1981). The pups stay on land 12 to 20 days before moving to the intertidal zone and initiation of water activity (Sandegren 1970) where they develop coordinated swimming behaviour before proceeding to deeper water. Pup mortality in British Columbia has been described as low (Pike and Maxwell 1958), but Mate (1973) found pup mortality at study sites in Oregon ranged from 22% to 83% depending on weather conditions. Drowning, stampede, rejection by the mother, and aggression by other females have been indicated as the important factors in pup mortality (Schusterman 1981). Life expectancy appears to be in the order of 30 years for females and 18 for males (Calkins and Pitcher 1982).

Body Growth: The mean weight of newborn pups is approximately 17 kg and early growth is rapid for both sexes, but sexual and physical maturity are reached after a long development period (Bryden 1972). Sexual dimorphism begins to be apparent in the first year (Schusterman 1981). Growth continues in males longer than in females but annual increases in mean length were found to be minimal after the age of 13 years (Thorsteinsen and Lensink 1962). Adult males weigh up to about 1 000 kg and females about 273 kg (Schusterman 1981).

Food and Feeding: Steller Sea Lions are opportunistic predators that feed near land in relatively shallow water (Fiscus and Baines 1966). The main foods are codfish, herring, rockfish, flatfish, squid, and octopus (Spalding 1964; Fiscus and Baines 1966; Calkins and Pitcher 1982). Although primarily nocturnal feeders they may hunt larger schools of prey during the day (Schusterman 1981). They may feed singly or in small groups, but usually group feeding is associated with large schools of prey as this behaviour is thought to aid in controlling schooling fish and squid making easier their exploitation (Fiscus and Baines 1966).

Seasonal Movements: In Alaska, Steller Sea Lions congregate on rookeries during the breeding season and are thought to migrate locally in winter (Alaska Department of Fish and Game 1973; Calkins and Pitcher 1982). The direction and distance travelled are unknown, although tagging and branding studies undertaken in Alaska and British Columbia indicate that dispersion

distances can be large. In April to June, juveniles were seen at haulouts up to 1 500 km from their birth sites (Fisher 1981; Calkins and Pitcher 1982). These juveniles were marked on Marmot Island, Alaska, and on Cape St. James, British Columbia, and were seen on Baranoff Island and Cape St. Elias, Alaska, respectively.

Off California and Oregon, adult males are uncommon in winter and are believed to migrate north to British Columbia and Alaska (Bartholomew and Boolootian 1960; Mate 1973). Evidence for this movement comes from Scammon (1874) who recovered a spear-head made by Alaskan natives from the carcass of a male Steller Sea Lion taken off California in June 1870. In addition, Mate (1975) observed a peak in numbers of adult males off Oregon during May and August. These peaks are believed to represent the southern and northerly migration of animals between California and sites north of Oregon. No rookeries exist in Washington.

Most individuals seen on rookeries in British Columbia were probably born there. Homing to the birth site is suggested from tagging studies on pups of this species in Alaska (Calkins and Pitcher 1982). Also, behavioural observations on the rookery at Cape St. James, British Columbia, indicated that adult females tend to return to the same rookery each year (Edie 1977). Homing to the site of birth is a well known phenomenon in the Northern Fur Seal, the only other species of otariid examined for this behaviour (Kenyon and Wilke 1953). Thus, each rookery in British Columbia may be a separate breeding stock.

As in Alaska, local dispersion appears to take place after breeding in British Columbia, with some immigration and emigration likely. Seasonal changes in distribution are evident when the numbers seen in rookeries, year-round haulouts, and winter sites are compared between summer and winter (Table 2). In July, most animals were on rookeries and few on winter sites, whereas in December the reverse was true. Movements appeared to be mainly between rookeries and winter sites. Numbers on year-round haulouts did not vary much between July and December. Other data support the view that local movements exist. Departures from rookeries began in late July, and arrivals on to winter sites began in August, while departures were complete from winter haulouts by late May and arrivals on rookeries began in May. Also, an examination of year-round haulouts and winter haulouts for the occurrence of young-of-the-year (Bigg 1984) suggests that pups dispersed along the coast after the breeding season. By

December and January young were seen throughout coastal British Columbia, on most year-round haulouts and exposed winter haulouts. The distribution of young indicates that some movement exists between rookeries and year-round haulouts. A few cows with young were seen on rookeries through until April suggesting that they may not move off the rookery after the breeding season. Gentry (1968, 1970), also reported some cows and young at Año Nuevo Island, California, during winter.

The total number of Steller Sea Lions seen in British Columbia was larger in winter than in summer. The difference was larger than indicated in Table 2, in that the counts during winter were more likely to have been under-estimates than counts in summer. Yet, if all seasonal movements took place only within British Columbia, then the counts in winter should be smaller than those in summer as some natural mortality would take place between summer and winter. Assuming that the same proportion hauled out in winter as in summer, some immigration seems likely. Immigration of adult and sub-adult males could come from California and Oregon, as has long been suspected. Support for this possibility comes from the fact that only adult and sub-adult males were observed off southern Vancouver Island, at Race Rocks, Plumper Sound, and Ada Island (Bigg 1985). Some immigration could have come from Forrester Island, Alaska, where few sea lions were present in winter (Table 3). Little immigration probably comes from the more northern rookeries in Alaska. The closest is located in Prince William Sound, 1000 km to the northwest (Calkins and Pitcher 1982; Loughlin et al. 1984). Considering that juvenile dispersion can be extensive, some emigration no doubt exists.

Limiting Factors

The effects of exploitation on abundance of Steller Sea Lions are well documented. During the 1800s stocks in British Columbia and Alaska were depleted apparently by the native hunt for meat, hides, and oil. Numbers increased in the late 1800s and early 1900s when the incidence of native hunting was reduced (Newcombe and Newcombe 1914; Wailes and Newcombe 1929). From 1913 to 1968 Canadian populations were reduced by hunting for commercial and management purposes and in military operations.

As behavioural observations and tagging studies have indicated strong site fidelity (Edie 1977; Calkins and Pitcher 1982), each rookery may be representative of a separate breeding stock. The

killing operations may have had an effect on the behaviour, distribution and numbers of sea lions at specific rookeries and other sites. Persistent harassment at a rookery may drive animals to nearby rookeries but does not discourage the animals from eventual return. However, removal of all breeding animals and pups could lead to site abandonment, as happened at Watch Rock, or a change in the use of one of the sites, such as is thought to have occurred at Virgin Rocks and Pearl Rock where virtual elimination of breeding animals and pups led to the sites becoming year-round haulouts.

The lack of recovery of the British Columbia population following the end of control programs in the 1960s may be due to several factors. An annual increase at a rate of 7%/year would be expected but these animals may be competing with the increasing population at Forrester Island for food as the two stocks probably mix at some time during the year. Shifts in distribution, disease (leptospirosis), and competition with commercial fishing interests may also be limiting recovery through reduction of carrying capacity (through reduction of food supply) and through gear entanglements. Changes in distribution and abundance of prey species such as herring seem to limit distribution of Steller Sea Lions as evidenced off Vancouver Island in 1982 to 1984. Killer Whales (*Orcinus orca*) occasionally prey on the species.

Special Significance of the Species

In past years the Steller Sea Lion was valued in British Columbia for mink food and to some extent leather. Currently its carcass is not commercially valued. Natives in a few locations in British Columbia still eat the animal and use its vibrissae for ceremonial dress. The main interest in this species remains that of the fishermen who express concerns about the potential damage to fisheries and gear. Recent non-consumptive commercial interest has developed in nature tours to haulouts, particularly off southern Vancouver Island.

Evaluation

The Steller Sea Lion in British Columbia currently numbers 1/4 to 1/3 of the breeding population size in 1913. The decline up to the mid-1960s appears to be due mainly to killing for predator control and commercial operations. Despite the absence of killing since the mid-1960s, there is little evidence that the breeding population has shown any evidence of recovery to former

levels. Recovery may have been impeded by the growth of a large rookery just north of British Columbia, in Alaska. It is also possible that the species in British Columbia suffers from reduced productivity, of unknown cause, similar to some populations in northern areas of Alaska. However, the combined population in British Columbia and at Forrester Island, Alaska, may be at about the same level as during the 1900s. It is recommended that for the present time the species not be placed in any COSEWIC category.

Acknowledgments

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Status of the Atlantic Walrus, *Odobenus rosmarus rosmarus*, in Canada*

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Walrus in Canada range over much of the eastern and high Arctic and Hudson Bay. Populations in the Gulf of St. Lawrence and northwest Atlantic were extirpated by the mid-19th century. Present concentrations are found mainly in Foxe Basin and northern Hudson Bay. Neither a trend in abundance nor the present size of the Canadian population can be estimated from existing information. Walrus are generally found in areas of shallow water (less than 100 m deep) which support the benthic molluscs on which they feed. In winter, heavy ice restricts their distribution. Exploitation is limited to native subsistence use and is the single most important factor limiting population size beyond natural mortality. Natural mortality and other factors affecting fecundity have not been quantified. Walrus populations in Canadian waters appear to be stable for the present and not in any COSEWIC category, but careful management involving native users is required for conservation of the existing populations.

Au Canada, l'aire de répartition du Morse couvre la majeure partie de la baie d'Hudson et des secteurs est et nord de l'arctique. Des populations du Golfe de St. Laurent et de l'Atlantique nord-ouest ont été extirpées au milieu du dix-neuvième siècle. De nos jours, on trouve des concentrations principalement dans le bassin Foxe et le nord de la baie d'Hudson. L'information disponible sur ces populations ne permet pas de déterminer une tendance démographique ni le nombre exact de Morses au Canada. En règle générale, le Morse fréquente les eaux peu profondes (moins de 100 m de profondeur) où se trouvent les mollusques benthiques dont il s'alimente. En hiver, son aire de répartition est limitée par la formation des glaces. La chasse n'est plus pratiquée que pour la subsistance mais, à part, la mortalité naturelle, elle est le facteur limitant le plus important du nombre de Morses. La mortalité naturelle ainsi que les facteurs influent sur la fécondité n'ont pas été quantifiés. Au Canada des populations du Morse semblent stable actuellement, et elles ne sont pas dans aucune catégorie du CSEMDC. Cependant, des recherches et une gestion prudente impliquant les chasseurs autochtones seront nécessaires pour assurer la conservation des populations actuelles.

Key Words: Atlantic Walrus, *Odobenus rosmarus*, odobenids, pinnipeds, marine mammals, Arctic mammals.

It is thought that the Odobenidae had a common origin with the Otariidae in the early Miocene from an ancestral aquatic group with close affinity to a primitive ursine carnivore (Repenning and Tedford 1977). This ancestral, primitive walrus-like pinniped originated in the North Pacific Ocean (Ray 1976) but only one form has survived to the present. Ancestors of the modern form probably migrated from the Pacific to the Atlantic via the Central American Seaway about 5 to 8 million years ago and subsequently the Pacific stock(s) became extinct. The North Pacific was then repopulated from the Atlantic via the Arctic Ocean in the late Pliocene, within the last million years (Repenning 1976).

The single species of modern Walrus (Figure 1) is one of the largest pinnipeds and is easily

recognized by its large canine teeth or tusks. The skin of adults is dark brown and covered with a short sparse brown coat of hair. The newborn has a foetal coat of silver grey hairs which it loses shortly after birth and is replaced by a coat similar to the adults. Males develop large muscular necks covered with tough, cornified skin. They also grow broader and longer tusks than females (Mansfield 1964).

Two subspecies are recognized, *Odobenus rosmarus rosmarus* Linnaeus, 1758, the Atlantic Walrus; and *Odobenus rosmarus divergens* Illiger, 1811, the Pacific Walrus. A third subspecies, *Odobenus rosmarus laptevi* Chapkii, 1940, has been suggested by Soviet biologists but the taxonomic status of this population is uncertain. Fay (1982) suggests that this population should

*After careful review of the present status of the species, extant Atlantic Walrus populations in Canadian waters were determined by COSEWIC (7 April 1987) to be not in jeopardy or, any COSEWIC category. The former population of the Northwest Atlantic coast and the Gulf of St. Lawrence was declared to be extirpated.

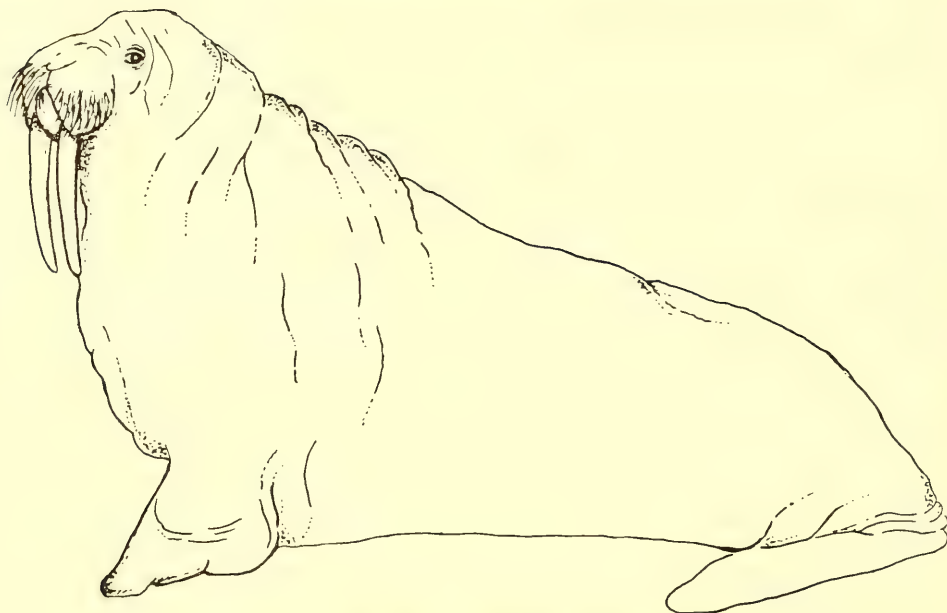


FIGURE 1. Atlantic Walrus (*Odobenus rosmarus rosmarus*).

probably be included with *Odobenus rosmarus divergens*.

The Pacific subspecies is generally 4 to 7% larger than the Atlantic form and develops larger tusks (Heptner et al. 1976; Fay 1982). The adult male Pacific Walrus has a broader snout and more massive neck and shoulder musculature than its Atlantic relative (Allen 1880; Fay 1982). On the average Atlantic Walrus in Canadian waters weigh 55 kg at birth and measure 1.2 m standard length. Adult females reach a mean weight of 560 kg and a length of 2.6 m while the larger males reach a mean weight of 900 kg and a length of 3.1 m. The largest recorded weight of a male Walrus in Canada is 1270 kg (Mansfield 1964).

Distribution

The modern Walrus is holarctic in occurrence; the animals principally inhabit the moving pack ice over the shallow waters of the continental shelf. They seem to prefer to haulout on ice but will use the land where there is no ice (Fay 1981). The distribution is not uniform and there are morphological differences between populations. At the present time there are thought to be six main populations (Figure 2) which appear to be geographically isolated (Fay 1982). The larger Pacific Walrus occurs in the Bering and Chukchi seas, and the five populations of the smaller

Atlantic Walrus are distributed in waters of the North Atlantic and Arctic oceans. These are: (1) in the Hudson Bay-Davis Strait region, (2) eastern



FIGURE 2. World distribution of Walrus showing the six populations (from Fay 1982).

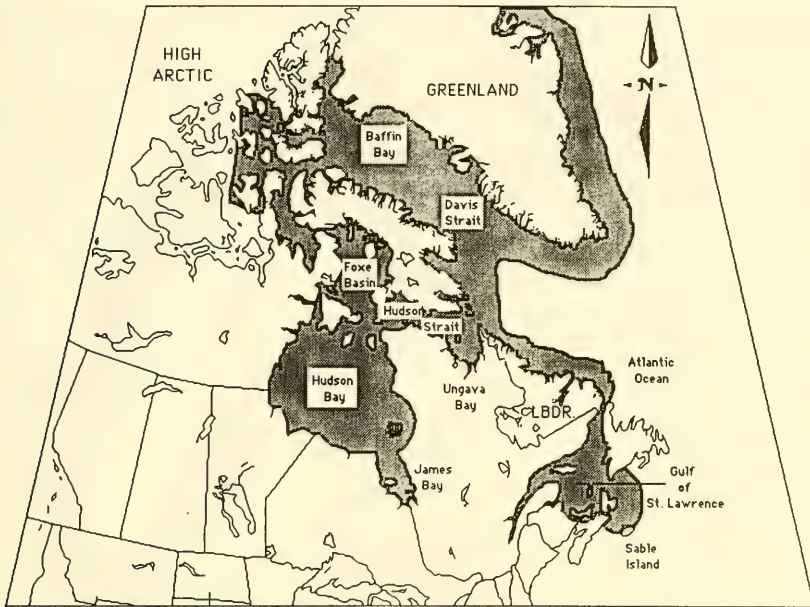


FIGURE 3. Approximate historical distribution of Atlantic Walrus in Canada [Based on Mansfield (1976) and Reeves (1978)].

Greenland, (3) Svalbard and Franz Josef Land, (4) Kara Sea — Novaya Zemlya, and (5) Laptev Sea.

Walrus distribution in North America ranges over the Bering and Chukchi Seas in the west where the large-sized Pacific Walrus occurs. Pacific Walrus have been sighted in the Canadian Beaufort Sea in summer and fall but these occurrences are exceptional (Fay 1982). The smaller Atlantic Walrus occupies eastern Canadian arctic and sub-arctic waters (Mansfield 1958). Historically, the Atlantic Walrus's range in Canada (Figure 3) included the eastern Arctic, the coasts of Hudson Bay and Labrador, as well as parts of the Atlantic seaboard and Gulf of St. Lawrence (Mansfield 1959; Reeves 1978).

As with other marine mammals the distribution may be related to climatic fluctuations (*see* Vibe 1967). Temperature, water depth and availability of suitable haul-out sites (preferably on ice) and adjacent feeding banks may also be important (Dunbar 1956; Harington 1966; Fay and Ray 1968; Reeves 1978). The Walrus may have ranged much further south during the great Ice Period. Fossil evidence indicates that the modern Walrus may have ranged as far south as Georgia and the Carolinas (Manville and Favour 1960). Although the Carolina records are questionable (Ray et al. 1968), the centre of Walrus abundance during the

Pleistocene was likely around the area of present day New York in the western Atlantic and southwest Britain in the eastern Atlantic (Davies 1958). It is obvious that the present range is much further north than that of Walrus during the ice age and that this "natural" expansion and contraction of the range constrains intelligible discussion of "original populations". For this paper "original population" is that population which existed when non-aboriginal people first made significant contact with the species: likely the 15th or 16th century in the northwest Atlantic and perhaps the 17th century for some large herds in the northeast Atlantic (Reeves 1978).

As a result of excessive commercial hunting in the last three to five centuries the present range of the Atlantic Walrus (Figure 4) is much reduced. By the mid-19th century Walrus had disappeared from Sable Island, off the eastern coast of Nova Scotia, from the Gulf of St. Lawrence (Mansfield 1959) and from all areas south of Okak Bay on the Labrador coast (Reeves 1978). Their numbers have also diminished in Ungava Bay, Hudson Strait, Davis Strait and Baffin Bay (Mansfield 1958; Loughrey 1959; Reeves 1978). Several land haul-out sites (*ugli*, plural *uglit* in the Inuit language) in Hudson Bay and James Bay have been abandoned (Loughrey 1959; Reeves 1978).

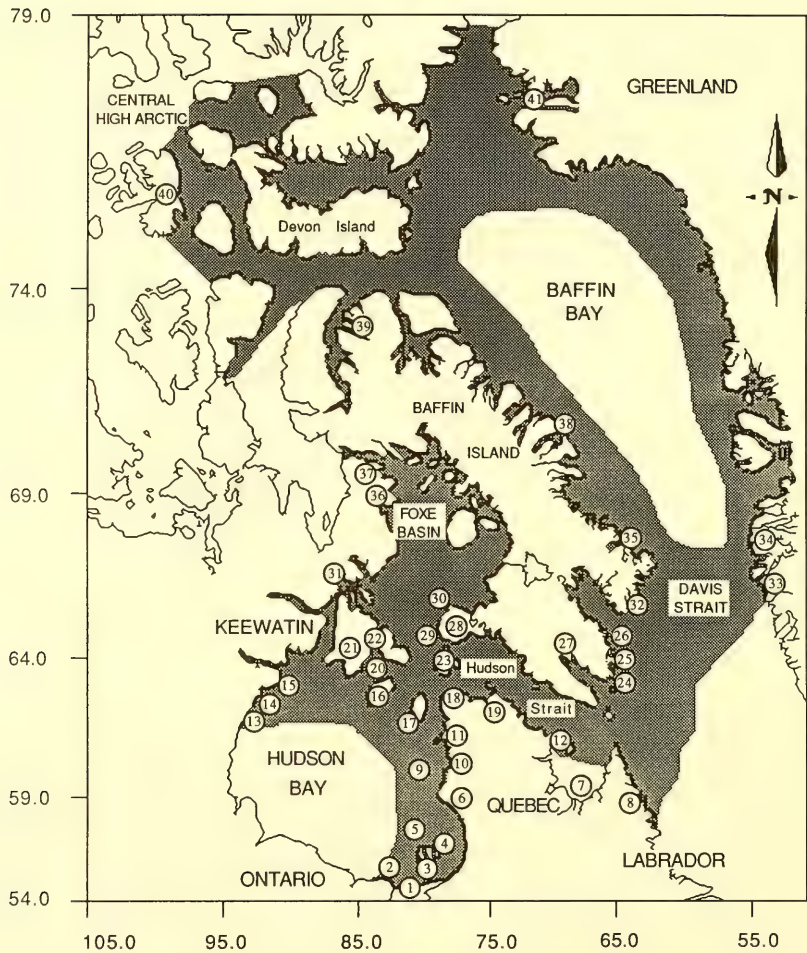


FIGURE 4. Present distribution of Atlantic Walrus in Canada (based on Davis et al. 1981): numbers refer to place names mentioned in the text:

Akpatok Island	12	Cyrus Bay Field	24	Okak Bay	8
Akulivik River	11	Evans Strait	20	Ottawa Island	9
Arctic Bay	39	Hall Beach	36	Povungnituk	10
Bathurst Island	40	Hoare Bay	32	Rankin Inlet	14
Belcher Islands	3	Holsteinsborg	34	Repulse Bay	31
Broughton Islands	35	Igloolik	37	Salluit	19
Cape Dorchester	30	Inukjuak	6	Sanikiluaq	4
Cape Dorset	28	Iqaluit	27	Sleeper & Kidney Island	5
Cape Henrietta Maria	2	Ivujivik	18	Southampton Island	21
Cape Queen	29	James Bay	1	Sukkertoppen	33
Chesterfield Inlet	15	Lady Franklin Island	25	Thule	41
Clyde River	38	Lemieux Island	26	Ungava Bay	7
Coats Island	16	Mansel Island	17	Whale Cove	13
Coral Harbour	22	Nottingham, Salisbury and Mill Islands	23		

This decline in Walrus populations appears to have been halted by regulations introduced in 1928 under the Fisheries Act which limited the hunting of Walrus to native subsistence use (Mansfield 1973). Presently, large concentrations of Walrus can be found in northern Hudson Bay and Foxe Basin (Mansfield 1966; Orr et al. 1986) while smaller concentrations are found scattered along the coasts of Davis Strait (MacLaren-Atlantic 1978; MacLaren-Marex 1979, 1980a,b), Baffin Bay (Finley and Renaud 1980) and the central High Arctic islands (Davis et al. 1980).

Another large concentration is also known to summer north of Baffin Bay along the northwest coast of Greenland (Mansfield 1973; Born et al. 1981) while smaller numbers are observed farther south along the west coast (Mansfield 1973; Kapel and Peterson 1982).

Protection

Walrus management in Canada is conducted by the Department of Fisheries and Oceans (DFO) under the authority of the Fisheries Act of 1867 and the Walrus Protection Regulations, as amended to date, which provide for the protection of habitat, management of the species, and control of the harvest.

The Walrus Protection Regulations limit Walrus hunting without permit to the Indian and Inuit natives of Canada. A native hunter may take up to four Walrus per year except in the settlements of Coral Harbour, Sanikiluaq, Arctic Bay, and Clyde River where catches are limited by annual community quotas (respectively 60, 10, 10 and 20).

These limitations were originally derived through negotiations with the appropriate communities of the Northwest Territories (NWT). Pending estimates of sustainable yield from Walrus populations, they were based on estimates of subsistence needs of hunters and were aimed at limiting use to subsistence hunting.

In addition, non-native hunting is controlled by licences which can be issued to a person who wishes to obtain food for himself, his family and his dogs. The Walrus Protection Regulations also establish conditions that should be met when hunting Walrus. They state that reasonable effort must be taken to retrieve any animal killed or wounded during a hunt and that wastage of any parts suitable for food is prohibited.

Export of Walrus meat from the NWT, Northern Quebec and Labrador north of 55°N, is prohibited, while export of other parts (including tusks) is controlled by DFO marine mammal

export permits. International trade is controlled through the Convention on International Trade in Endangered Species (CITES). Walrus is listed on Appendix III of the Convention; therefore any person wishing to export Walrus parts or derivatives from Canada must obtain an export permit from the Canadian CITES administration.

The measures described above offer a minimal level of protection to Walrus populations.

Population Size and Trends

There is meagre information on the history or current size of Atlantic Walrus populations. Walrus were apparently abundant in the Gulf of St. Lawrence, at Cape Breton Island and off Sable Island through the 17th century (Allen 1880; Allen 1930) and in the Gulf of St. Lawrence through the 18th century (Shulldham 1775; Ganong 1904). By the mid 19th century Walrus had been all but exterminated by excessive exploitation from all areas south of Labrador (Reeves 1978). Solitary stragglers are still occasionally sighted in the northern parts of the Gulf, off Newfoundland and in the Bay of Fundy (Lewis and Doult 1942; Wright 1951; Mercer 1967).

The remaining Walrus populations in Canadian waters exist in the north of the country in close association with the pack ice. The larger aggregations occur in northern Hudson Bay and Foxe Basin with smaller groups in Davis Strait, Baffin Bay and the high Arctic Islands, no further west than 100°W. No reliable method for estimating absolute numbers of Walruses has ever been developed (Reeves 1978) and most population estimates appearing in the literature are guesses. Reeves (1978) reviewed the status of the Atlantic Walrus and indicated that heavy commercial exploitation from about 1885 into the early 20th century had seriously depleted what must have been an abundant stock. As stated previously, this decline appears to have been halted by the introduction of the Walrus Protection Regulations by the federal government under the Fisheries Act in 1928.

Although absolute population estimates are not available, recent surveys conducted in areas of known concentrations compare favourably with the earlier estimates from the 1950s and early 1960s (Mansfield 1966). Counts have been obtained mainly during summer concentrations at haul-out sites. A few surveys covered areas of summer pack ice. Other areas not surveyed are known to have Walrus, but there is scant information on the numbers in these (Figure 5).

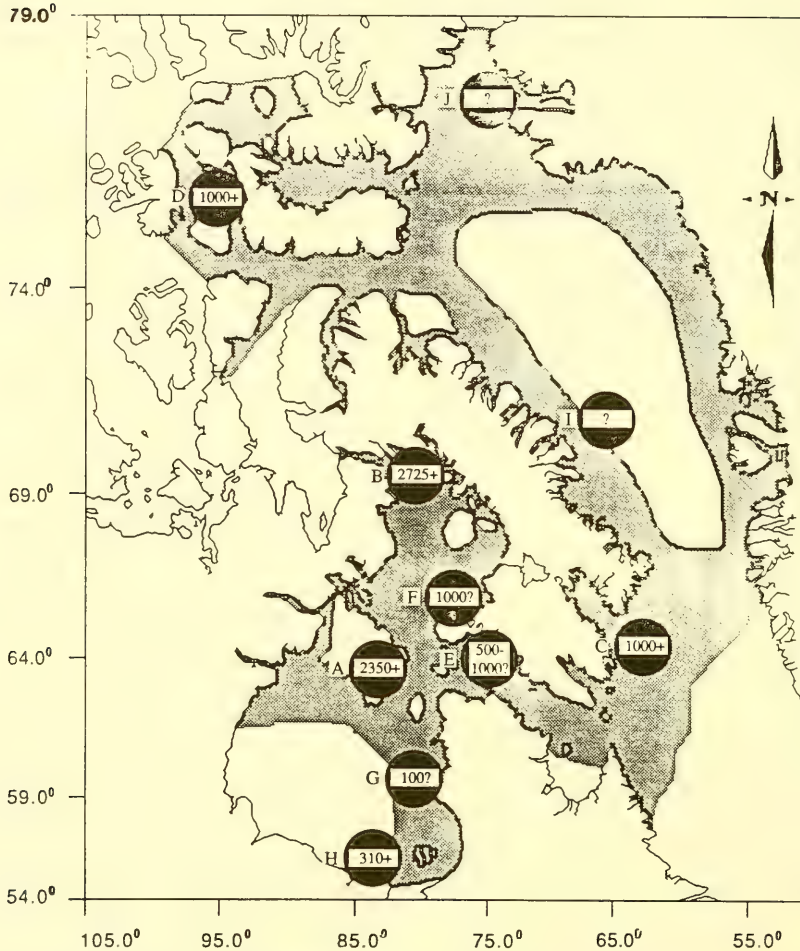


FIGURE 5. Location and number of Walrus counted during surveys or incidental sightings (in order presented in text): A — Southampton Island, Coats Island and Evans Strait; B — Northern Foxe Basin; C — Southeast Baffin Island; D — Central High Arctic; E — Salisbury, Nottingham and Mill Islands; F — Western Foxe Peninsula; G — Ottawa and Spicer Islands; H — Cape Henrietta Maria; I — East coast of Baffin Island; J — Northwest Greenland.

In northern Hudson Bay, all known ugilit of the Southampton-Coats Island area were surveyed by aircraft in July and August of 1976 and 1977. Haul-out sites were counted visually and photographed. The adjacent pack ice of Evans Strait was also surveyed by flying parallel transect lines spaced approximately 15 km apart. The largest total number counted in a day both at haul-out sites and on Evans Strait transects was 2350 on 26 July 1977 (A. W. Mansfield, DFO, Arctic Biological Station, Ste-Anne-de-Bellevue, personal commun-

ication). No estimate of population size was derived from these counts.

In northern Foxe Basin, observers counted 2716 Walrus during a helicopter survey along the edge of the pack ice on 19 and 20 of August 1983 (Orr et al. 1986). This reconnaissance survey covered only a small portion of northern Foxe Basin. It cannot be used to estimate population size.

Along the southeast coast of Baffin Island, a number of small ugilit were located during summer and fall surveys in 1977 to 1979 (MacLaren-

Atlantic 1978; MacLaren-Marex 1979, 1980a, 1980b). The largest ugli was on a small island near Lady Franklin Island where 600 to 700 Walrus were seen on 15 August 1979 (MacLaren-Marex 1980b). About a dozen other uglit were observed in the Lemieux Islands, in Cyrus Field Bay and in Hoare Bay (MacLaren-Atlantic 1978; MacLaren-Marex 1979, 1980a,b). The number of Walrus hauled out at each of these locations varied from a few individuals to about 100.

Finally, during surveys of the central High Arctic in 1976 and 1977, observers counted Walrus at uglit and on pack ice between Devon Island and Bathurst Island. They concluded that a minimum of at least 1000 Walrus were summering there (Davis et al. 1978).

There are several other areas which are known, from local sources or incidental observations, to be occupied by Walrus in summer. For example, Walrus have been reported to migrate west through Ungava Bay and Hudson Strait during summer, stopping to haul out at various locations such as Akpatok Island and various islands along the way with their final destination being Nottingham and Salisbury islands (Loughrey 1959). They were apparently very abundant on these last two islands and on Mill Island in the 1930s (Reeves 1978). Evidence for their continued presence in Ungava Bay was obtained in a few sightings during the 1978-1979 surveys (MacLaren-Atlantic 1978; MacLaren-Marex 1979).

Salluit hunters have been hunting on the northwest coast of Salisbury Island in recent years and approximately 200 Walrus were observed there in the fall of 1985 and 1986 (D. Allbright, Macdonald College, McGill University, Saint-Anne-de-Bellevue, Quebec, personal communication). Cape Dorset hunters report that Walrus are seen hauled out in late summer and fall on Mill, Salisbury and Nottingham islands in herds which vary between 500 and 1000 or more (Orr and Rebizant 1987). They also report that Walrus haul out at various locations in summer along western Foxe Peninsula, particularly between Cape Dorchester and Cape Queen, where they have apparently seen 1000 Walrus or more (Orr and Rebizant 1987).

Walrus are known to occupy the Ottawa, Sleeper and Belcher islands of eastern Hudson Bay (Loughrey 1959). Manning (1976) observed about 100 at the Sleeper and Kidney islands while travelling by boat in the area on 4-5 August 1971. Walrus are also occasionally taken on Mansel Island by residents of Ivujivik (Roy 1971).

Residents of the nearby settlements of Akulivik, Povungnituk, Inukjuak and Sanikiluaq (Belcher Islands) take an average total of approximately 36 Walrus per year (Table 1). Residents of Ivujivik also take about 30 a year, but they apparently take up to half of that catch on Salisbury or Nottingham islands (Roy 1971).

In western Hudson Bay, residents of the Keewatin mainland (Repulse Bay, Chesterfield Inlet, Rankin Inlet and Whale Cove) take a total mean annual catch of 23 Walrus. It is not clear whether these Walrus are the same that summer in the Southampton-Coats Island area.

In southern Hudson Bay, in summer and fall, observers have counted between 100 and 200 Walrus hauled out on shoals near Cape Henrietta Maria, Ontario. The largest count, 310 Walrus, was made in October 1978 (K. Abraham, Ontario Ministry of Natural Resources, Moosonee, Ontario, personal communication).

Walrus once occupied the Baffin Bay area in very large numbers (Davis et al. 1980). A large population of unknown size still occurs in the Thule area of northwest Greenland despite a large annual take by Greenland hunters (Mansfield 1973; Born et al. 1981). The relationship of this population with the one summering in the central High Arctic is unclear. Walrus are also found in several locations along the east central coast of Baffin Island, between the settlements of Clyde River and Broughton Island (Freeman 1976). Residents of these two communities take an average total of 29 Walrus per year (Table 1).

The counts presented above cannot be used to estimate the total Canadian Walrus population. They are simply counts of hauled out animals in some of the known areas of concentration or opportunistic sightings by various researchers and local informants. No information is available on the number of Walrus in the water at the time of these counts and on numbers in areas of lesser concentration.

Estimating population size of Walrus on pack ice is very difficult for several reasons. Walrus are gregarious by nature and they tend to be highly clumped in groups or herds. Their group size varies considerably and groups are often dispersed over wide areas of pack ice (Estes and Gilbert 1978). In addition, the proportion of Walrus hauled out on the ice can vary greatly from day to day (Estes and Gilbert 1978). These characteristics contribute to large sampling errors and consequently wide confidence limits.

In areas where the scarcity of ice in summer and fall forces them to haul out on land, Walrus tend to

TABLE 1. Reported annual Walrus catches in Canadian communities, 1972–1985. (sources: Department of Fisheries and Oceans: Yellowknife, NWT, and Quebec, P.Q.)

Community	Number of Reporting Years	Minimum Catch	Mean Catch	Maximum Catch
Resolute Bay	8	0	4	8
Grise Fiord	11	3	11	25
Arctic Bay	10	0	3	7
Pond Inlet	11	0	5	14
Clyde River	11	0	6	37
Broughton Island	11	5	23	49
Pangnirtung	13	0	29	125
Iqaluit	11	12	44	70
Lake Harbour	11	0	6	17
Cape Dorset	12	10	37	42
Igloolik	12	45	110	225
Hall Beach	13	30	96	200
Belcher Island	10	0	5	10
Whale Cove	9	0	2	6
Rankin Inlet	11	0	5	15
Chesterfield Inlet	10	0	4	15
Coral Harbour	14	11	46	103
Repulse Bay	12	0	12	35
Inukjuak	13	0	8	40
Povungnituk ^a	0	–	15	–
Akulivik	13	0	8	25
Ivujivik ^a	0	–	30	–
Salluit	13	0	27	73
Kangirsujuak	13	0	3	17
Quaqtaq	13	0	5	13
Kangirsuk	13	0	7	15
Kujjuak	13	0	1	15
Killiniq	13	0	1	4
			553	

^aPovungnituk and Ivujivik mean catches are rough estimates from local sources.

aggregate in a few predictable places (uglit). This facilitates counting of hauled out Walrus but the number of animals which remain in the water is still unknown. Again, the number of Walrus hauled out on land can vary widely from day-to-day and within the same day, as some Walrus leave for the sea and others return to the uglied (Salter 1979; Miller and Boness 1983; A. W. Mansfield, personal communication).

To estimate the size of Canadian Walrus populations, it will be necessary in the future to study the haul-out patterns of Walrus in detail and to design surveys so that sampling error can be substantially reduced. The surveys will have to cover the entire range of the Walrus's distribution at the time of survey. Alternatively, if different areas are surveyed independently, the question of relationship between populations must also be looked at closely.

Habitat

Walrus primarily inhabit shallow waters which support the benthic invertebrates on which they feed (Vibe 1950). They appear to be limited to water less than 80 to 100 m deep (Vibe 1950; Fay 1982). In winter, the presence of fast ice further restricts their distribution. They then seek areas of new ice where they can easily maintain holes, or large areas of water (polynyas) kept open by winds, tides or currents (Stirling et al. 1981; Fay 1982). Walrus are known to frequent polynyas in the High Arctic (Davis et al. 1980), northern Foxe Basin (Stirling et al. 1981) and Roes Welcome Sound (Degerbøl and Freuchen 1935), as well as the North Water of Baffin Bay (Finley and Renaud 1980).

Walrus prefer to haul out on ice (Fay 1982) but they use land haul-out sites, uglied, in areas where ice is dispersed or absent in summer. In northern

Hudson Bay, uglit are situated on low, rocky shorelines with a steep or shelving subtidal zone (Mansfield 1959); in other areas such as southern Hudson Bay, shoals and sand bars are also used (Mansfield 1959; Abraham, personal communication). Uglit of Alaskan waters are quite diverse, ranging from steep to gentle slopes with beach material varying from fine sand to massive rock outcrops (Fay 1982). It has been hypothesized that one of the benefits derived from hauling out on land as well as on ice is that it produces a stable temperature in the skin and appendages which promotes epidermal regeneration and the healing of wounds (Fay and Ray 1968).

Little is known about the underwater habitat of the Walrus. Several food species have been identified in Walrus stomachs but there is no quantitative information on the density and production level of the benthic invertebrates needed to support Walrus populations.

With their specialized diet, Walrus might be susceptible to accumulation of pollutants. Marine bivalves concentrate heavy metals such as arsenic and mercury. However, bivalves concentrate arsenic in an organic form which is less toxic and more prone to be excreted by mammals (Fallis 1982). Mercury and organochlorines have been detected in Greenland and Canadian Walrus but in relatively low concentrations compared with those found in other Arctic pinnipeds (Born et al. 1981). High levels of mercury were found in the liver of the Ringed Seal (*Phoca hispida*) but the seals showed no obvious toxic or pathological signs (Smith and Armstrong 1975). The toxicity of contaminants to Walrus is unknown.

Oil spills in areas occupied by Walrus might have deleterious effects by contaminating mollusc beds, especially if spills occurred in winter polynyas when Walrus would have little opportunity to seek other suitable uncontaminated areas. However, oil spills cause their greatest damage to the intertidal biota which is almost non-existent in ice-scoured Arctic waters (Johnson 1983). Walrus are known to feed at depths down to 80 m (Vibe 1950; Mansfield 1958) and mollusc productivity is probably greatest from 4–10 m to about 50 m where oil contamination is not likely to be great (Johnson 1983). Nothing is known of the toxicity of oil contaminants to Walrus.

General Biology

Reproductive Biology and Mortality: The Atlantic Walrus attains sexual maturity at about six or seven years of age and females give birth once every three years on average. The single calf is

born in May or June and nurses for one and a half to two years (Mansfield 1958). Gross annual production rate, or the proportion of newborns in the population, was roughly estimated by Loughrey (1959) to lie between 12% and 20%. Mansfield (1958) was more conservative in his estimate, suggesting an annual rate of production of 8%, but this was based on a small and probably biased sample of the age structure of the population. Using different assumptions on population parameters, he later revised his estimate to 11% (Mansfield 1973). This rate is comparable to those estimated for the Pacific Walrus population (Fay 1982). Samples obtained in 1960 from the latter population yielded a mean estimate of 14% (range = 12%–16%) while samples from 1972 suggested a mean rate of 17% (range = 15%–19%) per year (Fay 1982). Large samples are needed to estimate more precisely the present production rate of Canadian Walrus populations.

Natural causes of mortality include predation by Polar Bears, *Ursus maritimus*, and Killer Whales, *Orcinus orca*; calves and occasionally adults are trampled and killed at uglit when part of the Walrus herd stampedes towards the sea in response to a disturbance. Several pathological conditions have also been reported, some of which may result in death (Fay 1982). Samples obtained from Canadian Walrus populations have been too small to estimate mortality rates and, consequently, net annual production rates.

Feeding: Atlantic Walrus feed mainly on molluscs of three genera: *Mya*, *Cardium* and *Saxicava* (Vibe 1950; Mansfield 1959). Other benthic invertebrates such as annelids, crustaceans, holothurians and tunicates are presumed to be consumed opportunistically when Walrus pass over less suitable foraging grounds where molluscs are not dominant (Mansfield 1959). An average adult probably consumes between 34 and 74 kg of food per day which is equivalent to filling its stomach twice daily (Fay 1982). Observations of underwater pits and furrows left by feeding Pacific Walrus on bottom sediments in the Bering Sea indicate that they can eat more than six clams per minute during their average five minute dives (Oliver et al. 1983). One pit-furrow system was more than 60 m long and had 34 consumed clam shells discarded along the sides (Oliver et al. 1983). Average furrow length is about 47 m (Nelson and Johnson 1987).

Species movements: Walrus are thought to reside year-round in Foxe Basin and Hudson Bay

(Mansfield 1958; Loughrey 1959). In Hudson Strait, on the other hand, there seems to be a spring westward and fall eastward migration (Degerbøl and Freuchen 1935). It is not known if these migrants mix with the Hudson Bay Walrus (Davis et al. 1980).

Baffin Bay Walrus are also thought to migrate north along the Greenland coast in spring (Vibe 1950), and south along the Baffin Island coast in fall (Degerbøl and Freuchen 1935) but there is no evidence to support this (Davis et al. 1980). In fact, recent information from Walrus hunters indicates that northwest Greenland Walrus form a sedentary population (Born et al. 1981).

Behaviour and Adaptability: The choice of uglt is thought to be partly dependent on the amount of disturbance in their vicinity (Mansfield 1959; Fay and Ray 1968). Walrus abandon uglt during strong winds and heavy surf (Fay 1982). In such instances, an adjacent beach may sometimes be used (A. W. Mansfield, personal communication; Miller and Boness 1983) or the Walrus may move to other uglt (Mansfield 1959). They also take to the water to avoid excessive heat (Fay and Ray 1968; A. W. Mansfield, personal communication).

Walrus are sensitive to human disturbance. They react to approaching boats or low-flying aircraft by entering the water and swimming away (Salter 1979; Fay 1982; A. W. Mansfield, personal communication). In some cases, these escape reactions can take the form of a stampede in which animals may be trampled and killed.

The passage of large ships such as ice-breakers and oil tankers in areas of Walrus concentration is likely to cause similar disturbance. Walrus occupy channels and bays of the central Arctic archipelago which are close to sites of oil and gas exploration activity and proposed oil and gas transport ship passage. It is not known whether Walrus can adapt to non-threatening man-made disturbances such as boat or plane traffic.

While in the water, Walrus would be exposed to increased sound levels when in the vicinity of large ships, which could mask their communication or be uncomfortably noisy (Mansfield 1983).

Hunting is also a major source of disturbance at uglt. Conscious of that, Inuit hunters of Southampton Island are careful not to hunt Walrus too close to uglt for fear that they might desert these locations (Mansfield 1966; Freeman 1975).

Atlantic Walrus are very specialised in their food habits (*see* Feeding). Any reduction of the food sources is likely to have observable effects on Walrus populations. It is not known whether

Walrus seek new feeding areas if food densities become insufficient.

Limiting Factors

As stated earlier (*see* Reproductive Biology and Mortality), because of the small samples of Atlantic Walrus studied to date, we know very little quantitatively about natural mortality rates or about factors limiting fecundity rate. On the other hand, we have information on the removal through hunting.

Estimates of annual catches and of harvest losses have been collected by the Department of Fisheries and Oceans (DFO). The mean annual catch of Walrus in Canadian waters is approximately 550 (Table 1). More than one third of that catch is taken in Foxe Basin by the two communities of Igloolik and Hall Beach. These two settlements and six others (Coral Harbour, Cape Dorset, Igloolik, Pangnirtung, Broughton Island and Salluit) take about 75% of the annual catch.

The average annual catch per settlement calculated for all the settlements has not varied much from the overall mean between 1976 and 1985 (Figure 6). The average annual catch of the eight major hunting settlements mentioned above varies more about its overall mean, but there is no indication of an increasing trend in Walrus catches in the last decade (Figure 6).

With respect to hunting losses, it is estimated that 32% of Walrus killed during hunts in Foxe Basin are lost by sinking (Orr et al. 1986). This is consistent with the 20 to 30% loss rate observed previously on hunts in northern Hudson Bay (Loughrey 1959; Freeman 1970). When allowance is made for 20 to 32% loss rates, a rough estimate of average number of Walrus removed from Canadian waters every year is 690 to 810 Walrus.

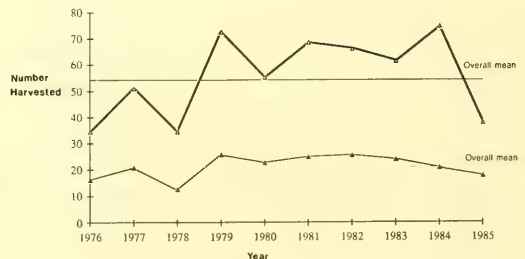


FIGURE 6. Mean annual catch of eight major Canadian Walrus hunting communities (top plot) and of all Walrus hunting communities (bottom plot): — Mean annual harvest of all hunting communities; — Mean annual harvest of 8 major hunting communities.

This estimate of removal indicates that hunting is an important factor limiting Walrus population growth.

Special Significance of the Species

The Walrus is the only extant species of the family Odobenidae. Although the size of the Canadian population is not known precisely, it remains the largest population of Atlantic Walrus in the world; European Atlantic Walrus populations probably number no more than a few thousand animals. The overall Atlantic Walrus population is smaller than that of the Pacific Walrus population which is estimated at over 200 000, but surpasses in size the Laptev Walrus population, which numbers about 4000 to 5000 (Fay 1981).

Walrus are an important source of food for many Inuit families and the hunt is an important cultural event in several communities (Freeman 1975; J. Orr, personal communication). Walrus are also of considerable interest to tourists, photographers and film makers from all over the world. The species will always be, like the Polar Bear, a readily identifiable symbol of the Arctic marine environment.

Evaluation

Historical information shows that the range of the Atlantic Walrus in Canada has been reduced by commercial hunting which took place in past centuries and as late as the early 1900s. Walrus Protection Regulations enacted in 1928 put a stop to commercial hunting and limited the taking of Walrus to native subsistence hunts. This has apparently halted the decline of populations but their current status is not known precisely. Populations in the Canadian Arctic appear to be in good condition. There is no evidence to suggest that the range reduction is continuing or that absolute population numbers are decreasing. On the other hand, since no reliable method for estimating absolute numbers exists, there is no direct evidence to the contrary. Regulations for the exploitation of Walruses and restriction of the hunt to native subsistence uses are under quota and this appears to have halted the decline of Canadian populations in this century.

That the Walrus formerly existed in considerable numbers and that the commercial exploitation of the species was also large is a matter of record (see Reeves 1978). Historical abundance is difficult if not impossible to extrapolate. The literature abounds with inaccuracies and guesses. Similarly, accounts of exploitation rates are also inaccurate

and confusing. Great care must be practised in the use of the older records in particular.

For example Perry (1968: p. 129) states without reference that "the Hudson's Bay Company exported 175,000 Walrus hides between 1925 and 1931 when the export of hides was prohibited by a Canadian Department of Fisheries Act". This unreferenced quotation has been cited by Chapman and Feldhamer (1982) and indirectly cited from Chapman and Feldhamer (1982) by McClung (1978) and others (Anonymous 1987) to indicate that large harvests during the early part of this century seriously depleted the stocks. This matter has been pursued to the source, the Hudson's Bay Company archives in Winnipeg, Manitoba, and it has been found that for the period 1925-1929, when there was a demand for hides, 165 963 pounds of hide were shipped from the trading posts in Hudson Bay, northern Québec, Foxe Basin and Baffin Island. After 1929 there was considerably less demand for hides, and after 1931 export of hides was prohibited (see Mansfield 1973).

Walrus skins were exported as half-hides weighing between 60 and 175 pounds; therefore an average weight per half-hide of 120 pounds was assumed for the years 1925 and 1926. In later years, Post Managers were told that half-hides weighing less than 150 pounds were not suitable for tanning. Thus, an average weight of 150 pounds for the half-hides shipped in those years was assumed. Based on these estimates, the 165 963 pounds of hides represent approximately 592 Walruses; that is, a catch of little more than 100 Walruses per year: a number considerably less than that some authors would have us believe.

It is obvious that Walrus were extirpated from their Canadian range in the northwest Atlantic by the mid-19th century (see Reeves 1978). Whether these animals were stocks discrete from those further to the north is problematical and evaluation of this question will have to await further taxonomic studies based on comparison of skeletal remains. However, the Atlantic subspecies is reported to be relatively sedentary, with a lesser tendency to wander seasonally than its Pacific counterpart (Mansfield 1958; Reeves 1978). For current management purposes it is safe to assume that the former stocks in the Gulf of St. Lawrence and along the eastern Atlantic coast of Canada were more or less discrete from those further north. There is no evidence to suggest that any significant reoccupation of this portion of the range has taken place (Reeves 1978) even though the species has had protection in this part of the range for many

years and stragglers are occasionally seen (Mercer 1967; Reeves 1978).

For management purposes, the question of geographical separation is of more immediate concern than taxonomic considerations. It is obvious that the northwest Atlantic stock of the Atlantic Walrus should be considered extirpated from Canadian waters.

Although the Walrus is closely associated with the distribution of pack ice and the cooler northern climate (Reeves 1978; Fay 1982), its distribution in northern areas may reflect an adaptation to exploitation and human encroachment on its habitat. Even though population and distribution data are not adequate for any area or period, there are indications that the distribution and numbers of Atlantic Walruses in the Canadian Arctic have declined here as elsewhere, at least until the early 20th century. Given that this decline occurred over the last 500 years, during a period of uncontrolled commercial exploitation, and that many of the factors prevailing then are not in force today, these should be looked at in a different light when examining the present situation.

The commercial exploitation of the species is certainly no longer a factor in Canadian waters but habitat encroachment through human disturbance in the present period of northern development could have an effect on the population. At the present time the annual removal by native subsistence use does not appear to cause continuing decline of Walrus populations, and legal trade of Walrus tusks is not a problem. In the period 1980–1984 an average of 5 tusks and 30 carvings per year were exported from Canada. There is no evidence of any illegal trade. The existing population of Atlantic Walrus in Canadian waters appears to be stable and at present does not fit the criteria for listing in any one of the categories recognized by the Committee on the Status of Endangered Wildlife in Canada.

However, current research and management measures are minimal, and there remains the requirement for accurate assessment of population numbers and vital rates and more rigid management control, if the future of the species is to be ensured. A large share of the responsibility for adequate management should fall to the user groups, in this case the Inuit. Involvement of the native people in the management of this resource, which is so important to their subsistence life style, is even more critical today as Inuit populations are increasing at annual rates of 3 to 7% (Fuller and Hubert 1981). Opportunities for wage economies are limited and great importance is being placed on the development of renewable resource economies.

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Status of the Fin Whale, *Balaenoptera physalus*, in Canada*

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Meredith, Gregory N., and R. R. Campbell. 1988. Status of the Fin Whale, *Balaenoptera physalus*, in Canada. Canadian Field-Naturalist 102(2): 351-368.

Fin Whales (*Balaenoptera physalus*) have a worldwide distribution with stocks being concentrated in temperate and cooler polar waters. All stocks are now considered "Protection Stocks" by the International Whaling Commission and commercial exploitation of the species has all but ceased. Whales of the eastern North Pacific stock may be found in the coastal waters off British Columbia during the summer months and two more-or-less discrete stocks inhabit the waters of the Continental Shelf off Nova Scotia and Newfoundland-Labrador in the western North Atlantic. Canadian and U.S. regulations have provided protection for all whales in Canadian and U.S. waters since 1972. However, commercial exploitation in the 20th century reduced most stocks in the Northern Hemisphere by 50% to 70% of the number of animals necessary to provide a maximum sustainable yield before whaling for Fin Whales was virtually ended in the 1970s. Although reliable population estimates are lacking, indices of abundance based on sightings indicate that numbers may be increasing. The species was almost certainly always rare in Canadian waters and "Canadian" stocks should continue to be considered vulnerable until it can be demonstrated that numbers are within 90% of the pre-exploitation stock level.

Le Rorqual commun (*Balaenoptera physalus*) est réparti à l'échelle du globe et les stocks sont concentrés dans les eaux tempérées et polaires plus froides. Tous les stocks sont maintenant considérés "stocks protégés" par la Commission baleinière internationale et l'exploitation commerciale de l'espèce a à toutes fins utiles cessé. Les rorquals du stock du Pacifique Nord oriental peuvent se trouver dans les eaux côtières au large de la Colombie-Britannique pendant les mois d'été et deux stocks plus ou moins discrets habitent les eaux du plateau continental au large de la Nouvelle-Écosse et de Terre-Neuve et du Labrador dans l'Atlantique Nord occidental. Les réglementations canadiennes et américaines assurent la protection de tous les cétacés dans les eaux canadiennes et américaines depuis 1972. Toutefois l'exploitation commerciale au 20^e siècle avait réduit la plupart des stocks dans l'hémisphère septentrional à entre 50 et 70 % du nombre d'animaux nécessaire pour assurer un rendement maximum soutenu avant que la chasse au Rorqual commun soit virtuellement stoppée à la fin des années 1970. Quoique des estimations fiables de la population ne soient pas disponibles, les indices de l'abondance basés sur les observations montrent que les nombres d'individus augmentent. L'espèce a presque certainement toujours été rare dans les eaux canadiennes et les stocks "canadiens" devraient être considérés vulnérables jusqu'à ce qu'il puisse être démontré que les nombres d'individus se situent à plus de 90 % de ce qu'ils étaient avant l'exploitation.

Key Words: Fin Whale, *Balaenoptera physalus*, baleen whales, cetacea, marine mammals.

The Fin Whale (*Balaenoptera physalus*) is the second largest of the whales, the Blue Whale (*Balaenoptera musculus*) being larger, the former reaching lengths of 22 m in males and 24 m in females, and weighing approximately 45 tonnes. The body (Figure 1) is very streamlined making this one of the fastest of the large whales able to swim at speeds of up to 36 km/h. They dive to moderate and deep depths, often remaining submerged for up to 20 minutes (Watson 1981).

As in other baleen whales the head is large and large baleen plates hang from the inside of the upper jaws. These plates are fringed with long hair-like cartilaginous fringes and act as a sieve to filter

out food from the water. The animals are dark gray above grading to white ventrally. The colouring of the head is strikingly asymmetrical; the left side being totally dark and the lower jaw on the right is white as are the baleen plates. This adaptive colouration is related to feeding behaviour (see Gambell 1985). As the whales feed on the surface they turn onto their right side and sweep the open mouth across the water leaving the dark colour exposed above and the lighter colour below.

Exploitation of the species for oil and meat early in this century reduced the numbers of some stocks to as much as 20% of their former levels. The cessation of whaling in Canadian and U.S. waters

*Rare status approved and assigned by COSEWIC 7 April 1987.

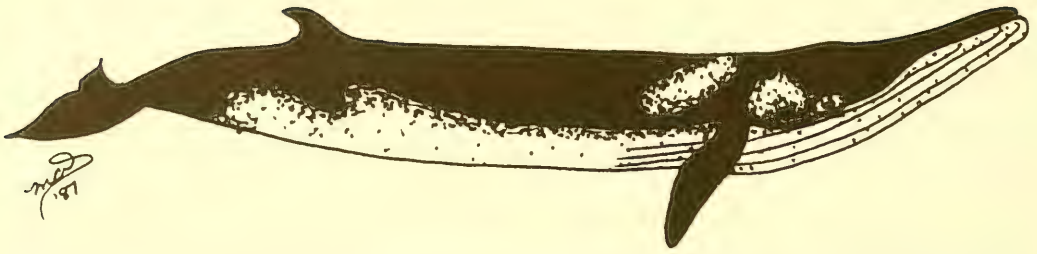


FIGURE 1. Drawing of the Fin Whale, *Balaenoptera physalus*, (Courtesy Department of Fisheries and Oceans, drawing by M. Service).

in 1972, followed by more rigid control of the harvests by the International Whaling Commission (IWC) starting in 1976 and subsequently by a complete moratorium on the killing of all whales, has provided the necessary respite for stocks to begin to rebuild.

Distribution

The Fin Whale has a world-wide distribution which is concentrated in temperate, arctic and antarctic waters (Figure 2). They tend to avoid the icepack and migrate toward the equator in winter, returning north (and/or south) in summer to feed in the productive coastal waters characterized by upwellings caused by coastal shelves or interfacing currents of differing temperatures (Gaskin 1972; Sergeant 1977; Nature Conservancy Council 1979).

Southern Stocks

Fin Whales are widely dispersed throughout the southern oceans and the identification of separate stocks* has been based on mark recoveries and analysis of migrations (Brown 1970), sociological evidence (Fujino 1964), morphometric measurements (Laws 1960) and iodine levels of Fin Whale oil (Lund 1951). However, the whales appear to be dispersed in their breeding areas and it is possible that Fin Whales exist in patchy continua, with one breeding stock in each of the southern oceans.

Northern Stocks

North Pacific: The distinctiveness of Fin Whale stocks in the North Pacific is not well documented (Mitchell 1973) but it is generally considered that there are two populations (Fujino 1960; Nishiwaki

1966). An eastern (east in respect of the Pacific Ocean) population summers in the Chukchi Sea and Bering Strait down to the coast of southern California and a western population along the Asian side to Japan (Figure 2). A small western sub-population exists in the East China Sea (Gaskin 1972). Some authors have arbitrarily divided the whole population into American and Asian populations along the line 180°W longitude (Omura and Ohsumi 1974).

In the eastern North Pacific Fin Whales winter off the coast of California south to around 20°N latitude. Many may also winter far out to sea, as far west as 138°–158°W longitude and south to 18°N latitude. In the summer, the whales are found in the immediate offshore waters from Southern California as far north as the Chukchi Sea (Rice 1974). Fin Whales may concentrate in summer along the Aleutian Islands and the Gulf of Alaska (Nishiwaki 1966). They are also found offshore of the British Columbia coast (Figure 3) but frequently they enter coastal areas such as those around the Queen Charlotte Islands (Pike and MacAskie 1969).

North Atlantic: Fin Whales are widely dispersed over the North Atlantic in areas of high biological productivity, with the northern limits set by ice and the southern limits by a maximum temperature tolerance of about 15°C (Sergeant 1977). In the eastern North Atlantic two possible stocks have been recognized (Figure 2) which summer off the coast of northern and western Norway respectively (Mitchell 1973). During the winter Fin Whales may be found off the east European coast as far south as the Canary Islands

*For management purposes some division into sub-populations is essential and to this end stocks have been defined as groups of individuals sufficiently isolated from neighbouring groups such that major changes in one group do not affect adjacent groups (see Allen 1980; Gambell 1985).



FIGURE 2. General world distribution of Fin Whale (*Balaenoptera physalus*) stocks. Arrows indicate north-south, winter-summer movements. In the Northern Hemisphere, summer feeding animals are distributed in the northern parts of the range, and move further south in winter. The reverse holds true in the Southern Hemisphere. East-west arrows indicate wide dispersion within the range. **Northern Hemisphere Populations** (largely from Gaskin 1972; Omura and Ohsumi 1974; Rice 1974). **Eastern North Pacific Populations** (largely from Gaskin 1972; Omura and Ohsumi 1974; Rice 1974): 1. American Stock, Western North Pacific; 2. Asian Stock; 3. East China Sea Subpopulation. **Western North Atlantic** (largely from Mitchell 1974; Sergeant 1977): 4. Gulf of St. Lawrence Stock; 5. Newfoundland Stock; 6. Nova Scotia Stock; 7. East and West Greenland Stock; 8. Iceland Stock; 9. North Norway Stock; 10. Southwest Norway Stock; 11. British Isles, Spain, Portugal Stocks; 11a. Mediterranean Sea Stock. **Southern Hemisphere Populations** (Ivashin 1969): 12. Chile-Peruvian Stock; 13. South Georgian Stock; 14. West African Stock; 15. East African Stock; 16. Grozet-Kerguelen Stock; 17. West Australian Stock; 18. East Australian Stock; 19. New Zealand Stock.

(Gaskin 1972). Records from the Mediterranean Basin (see Sergeant 1977) may indicate a resident population, however, Jonsgard (1966) indicates that migrations take place into and out of the Mediterranean Sea. The northern Norway stocks may also be related to the Iceland-East Greenland stocks (Figure 2); if so, the whales are distributed in a band across the Atlantic (Sergeant 1977).

In the western North Atlantic there may be two or more discrete populations (Mitchell 1974). Mitchell (1974) identified a relative distinctness in stocks exploited at Nova Scotia and at Newfoundland (Figures 2, 4) and Sergeant (1977) produced evidence for a small stock in the Gulf of St. Lawrence which may be part of the Nova Scotia stock (Mitchell 1974). Two possible stocks have also been recognized (Figure 2) around Iceland

and Greenland (Mitchell 1973). No evidence of interchange has been demonstrated between Fin Whales from the west Greenland area and the Newfoundland-Labrador-Nova Scotia area or the east Greenland-Iceland area (Mitchell 1974). There may be some interchange between east Greenland-Iceland whales and the Norway stocks (Mitchell 1973).

Canadian Distribution: The Fin Whale is one of the most abundant members of the Balaenopteridae found off the British Columbia coast. The species generally frequents offshore areas in the open ocean but has been reported from coastal areas (Figure 4) such as Hecate Strait, Queen Charlotte Sound and the Strait of Georgia (Pike and MacAskie 1969). The occurrence in Canadian

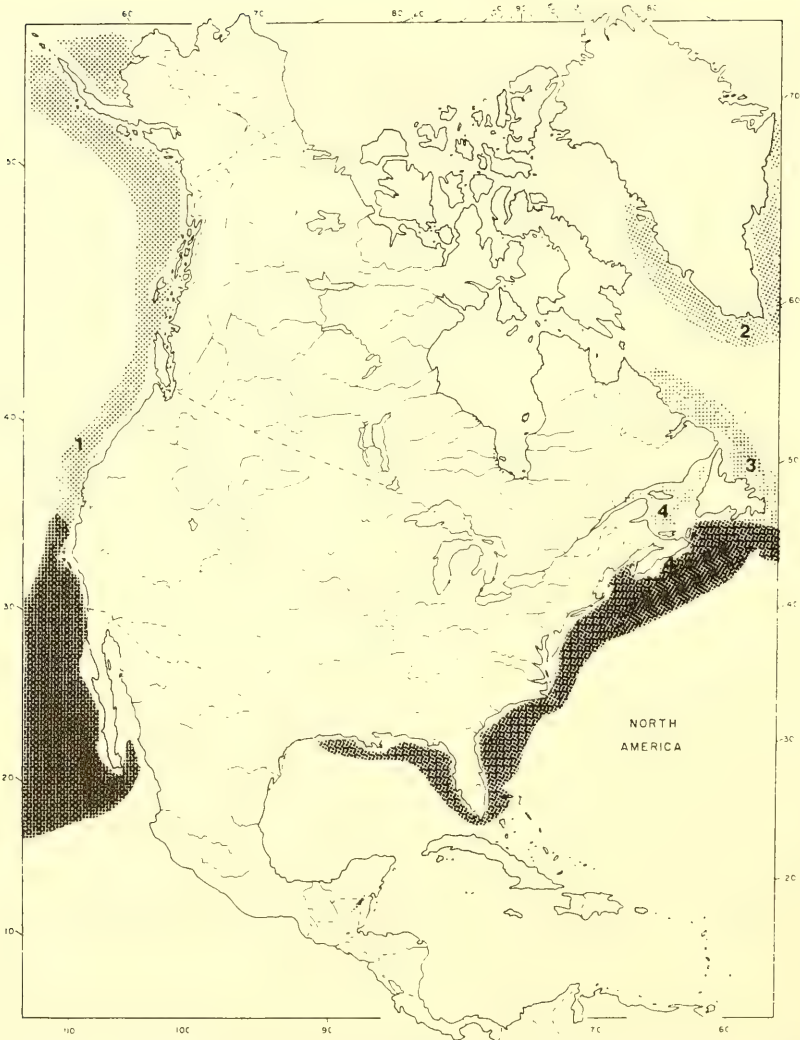


FIGURE 3. Approximate distribution of Fin Whales in North American waters (from sources cited in the text): Light stippling = Summer Distributions; Heavy Stippling = Winter Distributions: 1. Eastern North Pacific Population; 2. East-West Greenland Stock; 3. Newfoundland-Labrador Stock; 4. Nova Scotia-Gulf of St. Lawrence Stock(s?).

waters consists of animals migrating between summer feeding grounds in the more northern waters of the Bering and Chukchi Seas and the winter breeding grounds offshore of southern California (Pike and MacAskie 1969; Rice 1974). Some young animals may spend the summer off the British Columbia coast (Pike 1950).

Fin Whales are found in summer feeding concentrations in Canadian waters of the eastern North Atlantic between the shore and the 1 000 fathom line (1 828 m), from 40°20' to 57°00'N latitudes (Mitchell 1974). Populations may be stratified latitudinally with discrete stocks summering off Nova Scotia [42° to 45°N] and



FIGURE 4. Distribution of Fin Whale stocks in Canadian waters (chiefly Rice 1974; Mitchell 1974): 1. Eastern North Pacific Population; 2. Newfoundland-Labrador Population; 3. Nova Scotia-Gulf of St. Lawrence Stock.

Newfoundland [48° to 55°N] (Mitchell 1974). A small stock summers in the Gulf of St. Lawrence as far upriver as the confluence of the Saguenay River at Tadoussac, Quebec (48°N, 70°W) and may be to some extent, separate from the Nova Scotia stock (Sergeant 1977). Mitchell (1974) has shown that there is no interchange between the populations in the west Greenland or east Greenland-Iceland area with Nova Scotia and Newfoundland-Labrador stocks. Studies by Allen (1971) and Mitchell (1974) indicate a relative distinctness between the Nova Scotia-Newfoundland stocks, with maximum interchange of about 10%. Mitchell's (1974) evidence supports Kellogg's (1929) hypothesis that two overlapping populations exist; the southern population occupying the winter grounds of the northern population during the summer, with southward movement of both in winter. Brodie (1975) noted that Newfoundland and Nova Scotia Fin Whales differed in mean and maximum size and also suggested different feeding strategies for

the stock based on distributions in summer and winter.

Little is known of the winter distribution of Fin Whales of the northwest Atlantic (Sergeant 1977) and the breeding and calving grounds are unknown (Mitchell 1974). Fin Whales are known to winter along the North American coast as far south as 35°N (Mitchell 1974) and some Fin Whales have been sighted along the Continental Shelf from November to May, with the majority being north of 40°N (Slijper et al. 1964). Brodie (1975) reported Fin Whales off eastern Nova Scotia from December to May which may be representative of animals from the Gulf of St. Lawrence or the Newfoundland stock.

Protection

International

CITES: Fin Whales are listed on Appendix I of the Convention on International Trade in Endangered Species of Wild Flora and Fauna (*CITES*).

IWC: The International Whaling Commission (IWC) has established a moratorium on the commercial harvest of all whales. Additionally, all stocks (with the exception of the west Greenland, Newfoundland-Labrador, Spain-Portugal-British Isles, and north Norway stocks which are unclassified) have been listed (IWC 1986) as "Protection Stocks" [stocks which are below 10% of the level for maximum sustainable yield (MSY)]. Such stocks are protected from commercial whaling. The east Greenland-Iceland stock is listed as a Sustained Management Stock (SMS) (a stock which is not more than 10% of MSY below the MSY stock level, and not more than 20% above that level). SMS stocks may be harvested under quotas established by the IWC. Iceland has continued to take Fin Whales from this stock under Scientific Permit for research purposes. Similarly unclassified stocks may be harvested subject to quotas.

Provisions have been made for aboriginal subsistence harvests of whales and a small annual quota of (10) Fin Whales is allocated to the Greenland Inuit from the west Greenland stock (IWC 1986).

CRW: The taking of calves and mothers has been prohibited since 1931 under the terms of the Convention for the Regulation of Whaling (CRW).

National

Due to the cosmopolitan distribution of the species national legislative provisions relating to conservation involves nearly every country with a sea coast. For many of these countries regulation of whaling is based on IWC and/or CITES provisions as included in national law. Others, not members of the IWC respect such conventions and treaties as CRW and the 1937 International Agreement of the Regulation of Whaling (ARW). A complete listing is beyond the scope of this report and only those countries immediately concerned with the eastern North Pacific and western North Atlantic stocks are considered here. (For a more complete review see Nature Conservancy Council 1979.)

Eastern North Pacific

Canada: All whaling, except aboriginal whaling is prohibited in Canadian waters under the Cetacean Protection Regulations of the Fisheries Act of 1867 (as amended to date). Since 1982, Canada is no longer a member of the IWC but still provides data to the Scientific Committee and sends representatives to the Commission's Meetings as observers.

Japan: Whaling is regulated by licence from the Ministry of Agriculture and Forestry.

Mexico: The Federal Fisheries Development Act of 1972 provides enabling legislation to regulate all aquatic species in territorial waters on the Continental Shelf and the high seas.

USA: In addition to IWC and CITES provisions, protection is effected under the Marine Mammal Protection Act of 1972 and the Endangered Species Act of 1973. Aboriginal hunting is exempt but no Fin Whales are taken. In addition, the Fishery Conservation and Management Act of 1976 extended the jurisdiction of the Marine Mammal Protection Act to the 200 nautical mile zone from shore. This has prohibited foreign whaling in U.S. waters since 1976.

USSR: The USSR has a great many laws at various levels dealing with conservation and protection of endangered species (see Goldman 1972 for summary) but details are not available. Fin Whales are protected under the international obligations of the USSR and the Rules of Protection and Hunting of Marine Mammals of 1975 administered by the Ministry of Fisheries.

Western North Atlantic: Canada, Mexico, and USA; see above.

Greenland (Denmark): Regulation of whaling is controlled under enabling legislation based on IWC and CITES provisions and the Fin Whale is fully protected. Aboriginal subsistence harvesting is recognized and permitted from the west Greenland stock which is an unclassified stock.

Iceland: Whaling is regulated through the Regulations on Whaling of 1949 under the Act on Whaling of 1949. IWC protection of Fin Whale stocks is recognized but Iceland has continued to harvest Fin Whales from the unclassified east Greenland-Iceland stock under scientific permit.

Norway: Norwegian whaling is regulated under the Lov om Fanget av Hval of 1939 (with amendments). Norway has lodged an objection to the IWC moratorium and has continued to harvest Fin Whales under quota in Norwegian waters. Protection for the Fin Whale is under CRW which protects mothers and calves only.

Population Sizes and Trends

Because of its large size the Fin Whale was a prime target for the whaling industry and the development of the grenade harpoon and steam powered vessels made these fast swimming whales obtainable by the turn of the century (Gambell

1985). Northern stocks were relatively small and soon depleted and, with the advent of factory ships in the 1920s, the Fin Whale became an important part of the whale catches of the southern oceans, particularly the Antarctic where the species was the mainstay of the fishery through the 1950s (Gambell 1976).

At one time the Scientific Committee of the IWC put considerable emphasis on estimates of certain Fin Whale stocks to provide quantitative advice for management of those stocks which were being harvested. However, this emphasis has disappeared as the fisheries have declined or been extinguished in response to protective legislation or economic factors. Because of this subjective approach and the lack of continuation as fisheries declined or disappeared, the estimates now available are outdated and of variable reliability depending on the data base and the analytical methods employed.

The various whale populations and stocks varied considerably in the extent to which they were affected by whaling. Fin Whales have been categorized by Allen (1980) as a moderately exploited species with stocks being between 20 to 70% of pre-exploitation levels. The original abundance of Fin Whales in the southern oceans has been estimated at 490 000 whales at the beginning of this century with 103 000, or 21% now remaining (Allen 1980; Gambell 1985). Some estimates indicated that gross exploitation, particularly between 1955 to 1965, reduced the species in the Southern Hemisphere to as low as 70 000 whales (FAO 1976). The introduction of conservative management measures in the late 1960s and early 1970s prevented further reductions and in 1976 Fin Whale numbers in the Southern Hemisphere had increased to about 84 000 animals (FAO 1976; Gambell 1976) or 35% of the stock level required for MSY (Mitchell 1973). Allen (1974) calculated that a complete cessation of exploitation at that time would allow populations to reach to MSY level in 18 to 29 years and 90% of the original level in 50 to 60 years. There are no reliable recent estimates available but the estimate of 103 000 given by Allen (1980) and Gambell (1985) indicates the validity of Allen's (1974) calculations.

Very few estimates exist for the size of original stocks of the Northern Hemisphere where populations are more widely separated and stocks more distinct. Addition of Sergeant's (1977) estimate for the original stocks of Fin Whales in the North Atlantic (30 000 to 50 000 whales) with that of Omura and Ohsumi (1974) for the North

Pacific (42 000 to 45 000) gives an overall estimate of 72 000 to 95 000 Fin Whales in the Northern Hemisphere prior to exploitation. Exploitation reduced these stocks to 50 to 70% of the level that would produce the maximum sustainable yield (Mitchell 1973; FAO 1976; Gambell 1976) by the 1970s. Because of the problems identified previously it is not possible to produce current estimates and the scope of this report is more concerned with events related to Canadian waters. Examination of more pertinent aspects related to specific stocks can provide some insight into the current status of these whales in Canadian waters.

North Pacific: For convenience, assessments of Fin Whales in the North Pacific have usually been carried out by dividing the whale population (excepting whales in the east China Sea) into Asian and American stocks by 180°W longitude (Omura and Ohsumi 1974). This coincides fairly well with the east-west stock division described under the above heading. No estimates of the abundance of Fin Whales in waters off the British Columbia coast are available but a large part of the American or eastern population may migrate through Canadian waters during the yearly migratory cycle (Pike and MacAskie 1969). Thus, an examination of the American population will give some indication of the trends in population size in Canadian waters off the Pacific coast.

As it is important to know the historical change in the population and since there may be some intermingling of Asian and American stocks, they should be reviewed in totality as well as individually. Pelagic whaling did not commence on a large scale in the North Pacific until the 1950s following the collapse of the Antarctic fisheries but peak catches of Fin Whales were not achieved until 1965 as catches of Blue Whales began to decline (Allen 1980).

From 1910 to 1951 catches of Fin Whales from the Asian side of the North Pacific were in the order to 500 to 1 000 whales annually. On the eastern or American side, catches were less than 200 each year until pelagic operations began in 1954 (Ohsumi et al. 1971). These catches were mainly from land-based operations in Mexico, California, British Columbia, and Alaska. Some 20% of the yearly total of the eastern North Pacific catch was taken by Canadian whalers from British Columbia (Webb 1984). By 1950, stock size had been reduced to 30 to 40% of MSY on the Asian side with little or no reduction on the American side (Table 1) even though the Asian stocks were hunted well above the predicted MSY. That the Asian stocks did not decline more rapidly, and that

TABLE 1. Stock sizes and sustainable yield of Fin Whales in the North Pacific (Largely after Ohsumi et al. 1971).

Stock Size	Asian Side	American Side	Total North Pacific
Initial Stock Size	17 000–18 000	25 000–27 000	42 000–45 000
Stock Size 1959	9 970–12 090	24 930–26 450	34 900–38 540
Stock Size 1970	5 080–7 540	7 890–10 130	12 970–17 670
Stock Size 1980	**	**	16 000–20 000*
MSY Level	10 600–11 300	15 600–16 900	26 300–28 100
MSY	480–510	700–760	1 180–1 270

*Allen (1980)

**No current estimate

the American stock did decline rapidly, after the 1954 onset of pelagic whaling and increased harvests, may suggest that the two stocks were not totally discrete.

With the collapse of the Antarctic fishery in the early 1950s, pelagic whalers turned their attention to the North Pacific and the efforts of the Japanese and Russian factory ships were added to the existing American, Canadian and Mexican whaling industry already hunting from the American stock of Fin Whales. Catches increased yearly, peaking at 3 300 in 1964 then decreased rapidly. The American stock, which had remained fairly stable until 1950, decreased rapidly due to this intensive exploitation (see Table 1) and the stock size in 1970 was only about 51 to 60% of that required to support MSY (or 32 to 38% of the initial stock size).

Fin Whale catches from the eastern North Pacific stock were centered around California, British Columbia and Alaska, and, until 1955, most catches occurred off British Columbia, after which the catch around California began to increase. The Canadian west coast whaling industry had collapsed by 1967, prior to the Canadian ban on whaling in 1972, due to the failing profits related to decreasing abundance and accessibility of whales (Webb 1984). All Fin Whale catches off the North American west coast had ceased by 1972 and fin whaling in the North Pacific was ended entirely in 1976 under IWC prohibition (Mizroch et al. 1984).

Although population estimates from 1970 onwards are not available, Japanese scientists continue to produce abundance indices based on density indices (whales per 10 000 miles searched) and until 1976, catch statistics (Omura and Ohsumi 1974; Wada 1977, 1981). These indices indicated a significant decreasing trend in abundance of Fin Whales in the North Pacific until

1975 and an apparent increasing trend after 1976. Allen (1974) estimated that it would take 8 to 16 years for the North Pacific stocks to reach the MSY level and 25 to 30 years to reach 90% of the original level if exploitation was stopped. In 1981, the IWC Scientific Committee (IWC 1981) realized the need for new assessments of these stocks but no move to this end has as yet been initiated.

Western North Atlantic: Although the IWC recognizes several stocks in the North Atlantic (Figure 2) there is no evidence to suggest mixing between the eastern North Atlantic stocks and those of the western North Atlantic (Mizroch et al. 1984). Arnason (1981) suggested only one population for the eastern North Atlantic as the low productivity, high mobility and lack of physical barriers are not likely to result in "separate" populations. The situation may be similar in the western North Atlantic. Sergeant (1977) theorized that lack of evidence of discrete stock isolation and migration implies that Fin Whales in the North Atlantic exist "in a patchy continuum", with relatively small movements necessitated mainly by the search for food (Sergeant 1977: p. 471).

Despite the importance of the species to whaling interests, particularly in the 20th Century, there are very few estimates of original stock sizes in the North Atlantic. Gambell (1976) considered original stock size to be unknown; however, Sergeant (1977) estimated that the North Atlantic populations were never large, total numbers probably not less than 30 000 but not more than 50 000 whales. Nevertheless, it is clear that all stocks have been reduced through exploitation (Table 2). Allen (1974), summarized the situation in that the stocks off Canada have recently been reduced, the stocks off Iceland are probably stable, and the stocks are possibly overall below the MSY population level. A slow

TABLE 2. Initial and current population size estimates of Fin Whales in the North Atlantic.

Stock	Pre-exploitation	1960s	Current Best Estimate	Estimated % of initial population	Reference
Western North Atlantic					
Iceland	4 000–5 000	2 550	2 000 ¹	50	IWC (1981, 1982, 1984); Sigurjonsson (1985)
Greenland ^a	12 000–19 000	7 000	7 200	38–58	IWC (1981, 1982); Sigurjonsson (1985)
Newfoundland ^b	?	5 200 ²	1 900 ³	37	Mitchell (1974); Allen (1977); Sergeant (1979)
Nova Scotia	2 000	1 248	430 ³	22	Allen (1971, 1977); Mitchell (1974); Sergeant (1977)
Gulf of St Lawrence	?	340	?	?	Mitchell (1974); Sergeant (1977)
Eastern North Atlantic					
Norway ^c	7 000	?	Depleted	?	Sergeant (1977), Nature Conservancy Council (1979)
Spain ^d	9 600–11 400	?	1 200	11–13	Sergeant (1977); IWC (1981, 1983, 1984); Sanpera and Jones (1985)

^aEast and West Greenland¹1984

?No information

^bNewfoundland/Labrador²1966 — mean of several estimates^cNorway and Faroes³1976^dSpain, United Kingdom and Portugal

return to unexploited levels could be expected of stocks if exploitation ceased.

Since it appears that there is no mixing of stocks between the eastern and western North Atlantic populations, or between the Iceland-Greenland stocks and those around Newfoundland-Labrador and Nova Scotia (Sergeant 1977; Mizroch et al. 1984), the population trend discussion can be limited to those stocks in Canadian waters, without consideration of other North Atlantic stocks, although this subdivision of stocks has been questioned. At one time there may have been only a single stock in the North Atlantic which has become focussed in certain areas as numbers were reduced by whaling (Gambell 1985). However, this will probably not now be resolved and sufficient evidence does exist to make the stock distinctions utilized here (Mitchell 1974; Sergeant 1977; Mizroch et al. 1984). The precise relationships between the Newfoundland-Labrador stock and the Nova Scotia stock are not completely resolved and studies to date indicate about 10% mixing between the two (Mitchell 1974).

No estimates of the unexploited, initial stock sizes are available, but Sergeant (1977) surmised a minimum value in excess of 8 000 Fin Whales, based on a mean of Mitchell's (1974) calculations using various methods related to the 1966

population for Newfoundland and Nova Scotia. Of these, some 2 000 may have been of the Nova Scotia stock (Allen 1971; Mitchell 1974). Fin Whale catches in Newfoundland waters averaged 339 per year from 1903 to 1907, although many shore stations averaged 498 per year between 1903 and 1905. These early catches resulted in a decline in the number of whales available and forced a number of stations to close by 1907 (Mitchell 1974). Mitchell (1974) indicated that the sustainable yield in Newfoundland waters was about 400 Fin Whales per year or less, and that the unexploited Canadian population was probably not much larger than the 8 000 minimum proposed by Sergeant (1977).

Catch statistics (Mitchell 1974; IBWS 1930–1972) indicate a continuing, but sporadic, fishery with generally declining catches until 1945 (Table 3). From 1945 to 1951 an average of 464 Fin Whales per year were taken on the northeast coast of Newfoundland. Several factors, such as decreasing catches, decreasing length of whales taken, and a shift to less valuable species, pointed to over-exploitation (Sergeant 1966), and led Mitchell (1974) to conclude that the sustainable yield was less than 418 Fin Whales. Whaling off Newfoundland terminated in 1951, apparently as a result of falling oil prices, but this may have been

TABLE 3. Summary of principal Fin Whaling activity on the Canadian Atlantic Coast (mainly IBWS 1930-1972; Allen 1971; Mitchell 1974).

Period	Catches — Total and (Yearly Average)					
	Newfoundland-Labrador		Nova Scotia		Gulf of St. Lawrence	
	Total	Avg	Total	Avg	Total	Avg
1903-1905	1 495	(498)	-	-	-	-
1906-1909	1 002	(250)	-	-	-	-
1912-1915	620	(155)	-	-	56 (1915 only)	-
1923-1930	2 026	(253)	-	-	-	-
1935-1939	859	(215)	-	-	-	-
1940-1944	471	(94)	-	-	-	-
1945-1951	3 250	(464)	-	-	-	-
1964-1971	2 092	(299)	1 466	(210)	-	-

related as well to declining availability of whales (Mitchell 1974).

There have been two periods (Table 3) during which catches of 450 or more Fin Whales have been sustained over a number of years. This might suggest that the total sustainable yield for the Newfoundland-Labrador stock might be in the order of 400 whales. However, some of the whalers operated in areas fished by Nova Scotians and may have been taking whales from that stock (Allen 1971). Additionally, there appears to be 10% mixing between the stocks (Mitchell 1974) and immigration from Nova Scotia could also confound the issue. Nevertheless, the Newfoundland-Labrador stock was somewhat reduced during periods of heavy exploitation but is probably above the MSY population level, as postulated by Allen (1974).

The small number of Fin Whales (340) summering in the Gulf of St. Lawrence were fished from 1910 to 1917 (Mitchell 1974; Sergeant 1977). The numbers in this group have probably not changed much in this century and these whales may be part of the Nova Scotia stock (Mitchell 1974) although no definitive studies have been conducted.

There was no significant fishery for Fin Whales in the Nova Scotia region until 1964 (Mitchell 1974). The catch from this presumed stock comprised a total of 1 466 whales from 1964 through 1971 for an average of 183 per year (Table 3). Allen (1971) used catch and effort data to ascertain available stocks, estimating the initial stock (in 1966) to be in the order of 1 248 whales, and extrapolating the stock in 1970 to be 484. Updated estimates (Allen 1977) calculated a stock of 430 in 1976. It is clear from the rapid decline that the average catch was beyond the supposed MSY. Based on changes in abundance, and the difference

in effort of catches on this stock, and the Newfoundland-Labrador stock, Allen (1971) concluded that this was further evidence for distinctiveness of the two stocks.

Canadian whaling operations ceased in 1972 and no new estimates for these stocks are available. It is unfortunate that the driving force for obtaining such estimates is so closely linked to whaling. However, the stocks in Canadian waters are probably at, or above, the overall MSY population level and should slowly return to previous levels in the absence of whaling.

Habitat

The distribution of Fin Whales in northern waters is associated with coastal areas of relatively shallow depth along the Continental Shelf (Sergeant 1977). Ninety percent of Fin Whale sightings have been made in water of 27 to 256 m in depth (CeTAP 1982). These sightings correspond to the concentration of Fin Whales in coastal waters over the Continental Shelf. On the west coast Fin Whale distribution is also evidently associated with shallow offshore waters (Pike and MacAskie 1969).

It is widely accepted that the distribution of cetacea is largely dependent upon prey distribution (Kawamura 1980; Gaskin 1982). Temperate shallow areas of the oceans are known for their high productivity and it is in these areas that the prey of Fin Whales is distributed. In the North Pacific, the diet is composed of approximately 67% euphausiids, 26% copepods, 5% fish and 2% squid (Kawamura 1980). Fin Whales in the Nova Scotia region predominantly feed on euphausiids and some copepods while those in Newfoundland-Labrador waters prey almost exclusively on Capelin (*Mallotus villosus*) and herring (Mitchell 1975; Brodie et al. 1978).

Zooplanktors may constitute the basic food supply and pelagic fish, an additional supply. Fish concentrations along the Continental Shelf are well known and pelagic concentrations, especially of Capelin, have been associated with whale abundance (Whitehead and Carscadden 1985). Sergeant (1977) postulated that Fin Whales need make only small migrations from fish feeding zones to areas richer in plankton to survive. Blue Whales, on the other hand, are euphausiid specialists and thus must make long migrations.

General Biology

Life History: Male Fin Whales of the Northern Hemisphere reach sexual maturity at a body length of about 17.7 m, while the females become mature at a length of 18.3 m (Gambell 1985). In the Southern Hemisphere, Fin Whales have been found to reach the size of sexual maturity at earlier ages (Lockyer 1972; Ohsumi 1972). Pregnancy rates in the Southern Hemisphere have also changed as a result of exploitation and decreasing numbers to the effect that the average interval between successive births has been halved (Gambell 1985). Lockyer (1981) has found similar reductions in age of sexual maturity in Fin Whales off Iceland, although the evidence is not conclusive. Mitchell (1974) puts the age of sexual maturity for the Canadian stocks at 10 to 13 years and Lockyer (1981) has shown that, for the Icelandic stock, it is 8 to 11 years. The maximum life span may be up to 100 years (Gambell 1985) and physical maturity is reached somewhat later than sexual maturity. Growth is slower in the Northern Hemisphere than in the Southern Hemisphere (Pike and MacAskie 1969). Lengths for males and females may be 22 m and 24 m respectively (25 and 27 in the Southern Hemisphere) and growth rates may also be density dependent, although this is by no means certain (Gambell 1985).

Natural adult mortality is in the order of 4% as calculated from age composition data collected from landed catches (Allen 1980). This value has been generally accepted by the IWC (IWC 1983) and although small variations between stocks and sexes may be apparent, the general range is 3.5 to 5.5%. Van Beek (1982) suggested an adult mortality of 6% for the east Greenland-Iceland stock and indicated the juvenile mortality in the first two years could be as high as 66%. Gambell (1985) suggests juvenile mortality of 12% which agrees with the rate calculated by Van Beek (1982) for mortality over the first seven years of life. Mitchell (1974) calculated an average birthrate of

38.9% for the eastern North Atlantic stock in Canadian waters. Mitchell (1974) also provided an estimate for recruitment of females to the fishable stock (length of 15.2 m, age of 3 ear plug laminae or approximately 6 years) as $19.45e^{-3m}$ (where m is average natural mortality and e is the base of natural logarithms).

Reproduction: Fin Whales have a seasonal breeding cycle but the location of the winter breeding grounds is not well known for either the North Pacific or North Atlantic populations. In the North Pacific they may winter and mate off the coast of California, south to 20°N (Rice 1974). Fin Whales have been found to migrate along the coast and no significant numbers are found in southern waters during the summer months (Mitchell 1974) but the breeding and calving areas are not known, although breeding and calving is thought to occur in the winter months or early spring (Mitchell 1974; CeTAP 1982; Gaskin 1982).

The available evidence indicates that the Newfoundland-Labrador and Nova Scotia stocks have separate breeding and calving grounds (Mitchell 1974). The sex ratio at birth and throughout life is 1:1 but segregation during migration and exploitation could affect this (Gambell 1985). Mitchell (1974) has indicated that females comprise 56 to 61% of the Nova Scotia breeding population, as sampled from the landed catch.

The basic reproductive cycle is biennial and integrated with the usual feeding cycles. Conception is thought to occur over a five-month period during the non-feeding winter months, females are usually monestrous but may ovulate more than once in an estrus cycle if they fail to conceive; postpartum ovulations are rare (Mizroch et al. 1984). Recent investigations off Norway and Iceland have revealed that average conception times may vary between stocks and that reproductive activity is more pronounced in the spring than in the autumn (Haug 1981). There are suggestions that the pregnancy rate increases in response to exploitation (Gambell 1973) and this may be the case between mature females in Newfoundland waters and Nova Scotia waters. Mitchell (1974) found 43.3% of mature females sampled from the Nova Scotia stock were pregnant while 57.9 to 58.5% of those sampled from the Newfoundland stock were pregnant. Mitchell (1974) surmised that the difference may have been related to the longer and heavier periods of exploitation on the latter stock. Haug (1981) found similar differences in pregnancy rates between the north and west Norway stocks which have also

experienced differences in the degree of exploitation.

The gestation period is about 11.5 months and the single, precocial calf is born on the wintering grounds. Lactation may last six to seven months and the calf is weaned before the end of the summer on the feeding grounds (Mizroch et al. 1984). Lactation is followed by a resting period before mating again in the winter. This resting period may last another year if the female fails to conceive (Gambell 1985). There is some evidence to indicate that the ovulation rate may be influenced by density-dependent factors related to exploitation and/or food supply. Mitchell (1974) concluded that the ovulation rate, as indicated by females from the Nova Scotia landed catch, was approximately once every two years and for those females from the Newfoundland catch, once every three years. There is also some indication that the ovulation rate has decreased in Fin Whales from the Iceland and north and west Norway stocks (Lockyer and Brown 1979; Haug 1981). Changes in the ovulation rate, age at sexual maturity, and % of pregnant females may be related to a density-dependent effect arising from exploitation, or from an increase in available food. Lockyer (1978) indicated that the actual food supply has probably not increased but that the amount of food available to an individual has, due to decreases in the populations because of exploitation.

Nutrition and Growth: The calves are about 6 m long at birth and may weigh upwards of 1.9 tonnes. By the time of weaning (6 to 11 months) the calves may attain mean body lengths of 12 m and weigh up to 11 tonnes (Lockyer 1978; Mizroch et al. 1984; Gambell 1985). There is little information available on growth and survival of Fin Whales from birth to age 2 but growth is rapid and dependent on food supply; with poor food supplies, calves are not likely to survive. Lockyer (1978) found that the Von Bertalanffy formula of growth (Von Bertalanffy 1938) for describing growth curves of length with age in animals was suitable for use with Fin Whales, except in the first two years of life. Commencing with the second year, growth in Fin Whales can be described from this formula where:

$$L_t = L_a (1 - e^{-K(t-t_0)})$$

and L_t = length at age t ; L_a = length at age a (physical maturity); K = growth rate constant; t = age; t_0 = age constant.

Lockyer (1978) also demonstrated that the length at age curve can be converted to weight-at-age by applying: $W = 0.000255 L^{2.90}$ (L in ft, W in tonnes). There is, as mentioned previously,

evidence to suggest that growth rates and pregnancy rates have increased at least in the Antarctic (Gambell 1973; Masaki 1978) and perhaps in the North Atlantic as well (Mitchell 1974; Lockyer and Brown 1979; Haug 1981). Lockyer (1978) found that the growth rate has increased by as much as four-fold in some cases (in the Antarctic) and attributed this to an increase in food supply as a result of gross reduction in stocks of all whales.

We have previously referred to the food of Fin Whales particularly for the stocks in the Northern Hemisphere. In terms of nutritional requirements, the food necessary for the future growth estimated by Lockyer (1978) would be double the amount per pre-pubertal individual in the unexploited populations. Food requirements to meet maintenance energy demands alone may be in the order of 250 tonnes per year. Food consumption may be increased by up to 22% to produce the increased growth rates and reduction of age at sexual maturity (Lockyer 1978). For example, Lockyer (1978) suggests that an increase of 5% in the amount of food consumed could effect a reduction in age of sexual maturity by one year — even with reduction in age of sexual maturity the size at maturity has been found to remain constant. The increase in overall food availability required would be less than 5% because of age distribution structure. Mature whales, presumably, would not require additional food for growth.

Behaviour: Fin Whales are usually solitary animals found singly or in small groups of two to three animals (typically a male, female, and calf). Larger concentrations may be found, particularly when feeding on schooling fish (Nature Conservancy Council 1979; Gambell 1985). The species is one of the fastest swimmers amongst the whales, speeds of over 36 km/h have been recorded, and they have also been known to travel up to 292 km in one day (Gambell 1985).

These whales feed by engulfing the prey in a mouthfull of water and forcing the water out through the baleen plates as the mouth is closed, leaving the food organisms behind to be swallowed. Fin Whales have a unique, asymmetrical colour pattern that is in accord with feeding behaviour (Gambell 1985). The left side of the head and the baleen plates of the left mandible are pigmented evenly while the front of the lower jaw and the baleen plates on the right, are white (sometimes yellow on the baleen plates). Watkins and Schevill (1979) have reported that Fin Whales feeding on the surface swim on their right sides and make lateral scoops with the mouth open and throat distended (Figure 5).



FIGURE 5. Fin Whale engaged in energetic side feeding among large surface swarms of *Meganyctiphanes norvegica* and school of Atlantic Herring (*Clupea harengus harengus*) and Mackerel (*Scomber scombrus*) off Brier Island, Nova Scotia, August 1974 [Photograph by D. E. Gaskin; from Gaskin (1982) by permission].

Species Movement: The Fin Whales undergo regular seasonal migrations between temperate waters, where they mate and calve in winter, and the summer feeding areas in cooler, more polar, waters (Gambell 1985). The migrations in the Southern Hemisphere are perhaps more distinct and better documented than those in the Northern Hemisphere. The northern and southern populations do not converge towards the equator at the same time because of the opposition of the seasons in the two hemispheres, i.e., southern whales are six months out of synchrony with northern whales. It is possible that some interchange of individuals does occur (Gambell 1985).

In the eastern North Pacific, Fin Whales are found in the summer in the Chukchi Sea, around the Aleutian Islands, the Gulf of Alaska and down the coast to California (Figure 3). During the winter they are seen off southern California, south

to Baja California, and many may winter out to sea between 17° to 37°N latitude and west to 158°W longitude (Rice 1974; Gambell 1985).

In the North Atlantic, Fin Whales spend the summer months from the region of Cape Cod north to 75°N latitude, around Greenland, Iceland, North Norway, Jan Mayen, Spitzbergen, and the Barents Sea. Some Fin Whales are present in the Mediterranean the year round (Gambell 1985). During the winter, the whales are found from the ice edge south to the Caribbean and the Gulf of Mexico in the west, and from southern Norway to the Canary Islands in the east (Gambell 1985). In the Southern Hemisphere, migrations are characterized by sexual and age-class segregation but this behaviour is not as apparent in the Northern Hemisphere (Gambell 1985) although Mitchell (1974), has suggested there may be categorical segregation in the migration of Fin Whales along the Canadian coast.

There appears to be a north-south migration along the North American coast and winter records exist as far south as North Carolina, Florida, and the Gulf of Mexico (see Mitchell 1974). The whales appear to follow the Continental Shelf and there is no evidence of onshore-offshore migrations to the mid-Atlantic or in the north to the Denmark Strait (Mitchell 1974; Sergeant 1977). In the summer feeding concentrations in Canadian waters are concentrated at 42° to 45°N latitude (Nova Scotia stock) and 48° to 55°N latitude (Newfoundland-Labrador stock) with a small group in the Gulf of St. Lawrence (Mitchell 1974; Sergeant 1977). Mitchell (1974) has indicated there may be about 10% mixing between the two stocks during the year. It has been suggested that the Nova Scotia stock move south in the winter along the American coast and the Newfoundland-Labrador stock shifts slightly to occupy the summer grounds of the Nova Scotia stock during winter (Kellog 1929; Mitchell 1974; Sergeant 1977). Sergeant (1977) indicated that mean seasonal displacement for whales along the Canadian seaboard was probably not more than 600 km.

Limiting Factors

In the past, exploitation of the Fin Whale was reflected by a decline in stock sizes. Over the last decade, the cessation of exploitation appears to have been followed by an increase in numbers. All stocks are now afforded complete protection by the IWC and the Canadian and US Governments. At present, exploitation can no longer be considered a threat to the species, especially in Canadian waters. However, should harvesting be permitted in future, careful management will be required to prevent the depletion of stocks observed in the past.

Fin Whales appear to be associated with highly productive coastal waters, and along the eastern North American coast they exploit whatever food resource is most readily available. These food resources, however, must be available in large quantities and, therefore, the distribution of Fin Whales is largely dependent upon areas of high productivity such as those of the Continental Shelf in temperate zones. Whitehead and Carscadden (1985), for example, have shown that inshore whale abundance is related to Capelin distribution and abundance. This is an important consideration as there are few areas in the oceans that offer such high productivity and, therefore, the food resource is limited, implying that there is a finite level of abundance of whales able to be supported by this resource.

Causes of natural mortality for the species are unknown. Killer Whales (*Orcinus orca*) may prey on younger animals. Fin Whales are relatively free from ectoparasites and endoparasites. The few endoparasites (helminth) that are known to infect the species appear to be non-pathogenic (Mizroch et al. 1984). Hodgkinson's disease (*Granuloma malignum*) has been recorded in the species (Simpson and Garner 1972). Fin Whale strandings have been related to human causes (pollution, whaling) and natural mortality (Sergeant 1977).

The susceptibility of Fin Whales to the effects of pollution are not well documented, but since these animals are at the end of the food chain, they are vulnerable to chemical pollution. Viale (1974; Viale et al. 1973) has indicated that the dumping of industrial wastes at sea has increased heavy metal concentrations around Corsica. Fin Whales are contaminated through the euphausiids in their diet and it is thought that this has led to debilitation, death, and increased susceptibility to being struck by boats in the area. Aguilar and Jover (1982) have found DDT and PCB levels in Fin Whale tissue, detectable at levels sufficient to risk the health of the animals. The levels of PCB's show a progressive increase since 1967. DDT levels have decreased of late, concurrent with the restrictions on its use. Although other organochlorines were detectable, none were at levels to be of concern (Aguilar and Jover 1982).

In the last decade, offshore oil exploration development has proceeded apace on the eastern Continental Shelf and the possibilities of an oil spill from a shipping accident, or from development, is of particular concern. There is little evidence to suggest that oil contamination or ingestion would be irreversibly harmful (Hoffman and Bonner 1985) to most marine mammals. Geraci and St. Aubin (1982) have concluded that contact with oil may have no detrimental long-term effects on cetaceans.

A number of other species of whale, seabirds, and fish, use the same prey as Fin Whales. Competition between stocks and species may exist to some extent because habitat and food are a common, finite, resource. The absolute number of whales which can be supported in a particular area is limited by the size of the area and the amount of food available in it. Mitchell (1975) has considered the interactions between Fin, Humpback (*Megaptera novaeangliae*) and Minke Whales (*Balaenoptera acutorostrata*) off eastern Canada, where these species have similar food requirements. There are indications that the presence of one of these species may affect the feeding

efficiency of the others (Whitehead 1981) but there is no evidence to suggest this has been limiting. The decimation of whale stocks in general, through exploitation, has probably led to an increase in the amount of food available (Lockyer 1978) and until populations reach pre-exploitation levels, inter-specific competition would not likely pose a limitation to population increase. Commercial fisheries may pose more of a threat, particularly where these fisheries are directed to a principle prey species. Commercial interests may reduce fish stocks or change behaviour patterns in such a way that the prey is no longer available. Whitehead and Carscadden (1985) have shown that whale distribution and abundance off the Newfoundland coast has shifted, concomitant with the distribution and abundance of the principle prey, Capelin. The extent of the effects of the commercial Capelin fishery on the availability of food for whales is disputed (Carscadden 1983) but it is clear that the potential for serious limitations exists.

Special Significance of the Species

The Fin Whale is one of the largest whales, second only to the Blue Whale. It is also reported to be one of the fastest, if not the fastest, of all large whales (FAO 1978). The Fin Whale was the mainstay of Antarctic pelagic whalers from 1938 to 1964, longer than any other species (FOA 1978) and became an important species to pelagic whalers in the Northern Hemisphere, following the collapse of the Antarctic fishery.

Although heavily hunted for meat and oil in the past, whaling for Fin Whales has virtually ceased as all stocks are considered Protection Stocks by the IWC. Fin Whales have been protected in Canadian-U.S. waters since 1972. A small aboriginal fishery still exists in Greenland, and Iceland and Norway continue to take Fin Whales, presumably within the MSY of the relevant stocks.

The bulk of the take of these existing fisheries is consumed locally and no international trade (except for exports from Iceland), legal or otherwise, exists at present. Should the IWC moratorium be lifted, potential lucrative markets for oil and meat would be extensive. The potential for trade in live species is nil because of the size of these animals. The oil and meat, the principle materials of trade, are difficult to distinguish from those of other large cetaceans and whale products are usually shipped in mixed species consignments. Standards for oil and meat are concerned only with quality and colour, not with species of origin (Nature Conservancy Council 1979).

Evaluation

Canadian Fin Whale stocks were reduced by heavy exploitation in the mid-part of the 20th Century. All stocks in Canadian and U.S. waters have received full protection since 1972.

The eastern North Pacific stock is not uniquely Canadian, but has been declared an IWC Protection Stock and has not been hunted since 1976. Fin Whales in the eastern North Pacific were reduced to 32 to 38% of the initial stock size by 1970 (Ohsumi et al. 1971). Indices, based on catch statistics and whale sightings, indicate that the numbers are increasing (Wada 1977, 1981) but it could take another 25 years, or more, for the stock to reach 90% of the pre-exploitation levels (Allen 1974) assuming exploitation is not resumed.

Stocks unique to Canadian waters do exist in the western North Atlantic where similar reductions took place due to exploitation (Mitchell 1974; Whitehead and Lien 1982). The Newfoundland-Labrador stock is probably at, or above, the MSY level, and the Gulf of St. Lawrence stock (which may not be a discrete stock) is probably not much changed from original levels as these whales experienced little exploitation (Allen 1971, 1974; Mitchell 1974). The Nova Scotia stock, on the other hand, may be at 35%, or less, of the initial stock size.

Fin Whales have never been numerous in the Northern Hemisphere (Sergeant 1977; Gambell 1985) and stocks in Canadian waters, even at original stock levels would be classified as rare. Although all stocks seem to be increasing in numbers, there have been no recent, reliable population estimates. Given that these whales were never numerous in northern waters to begin with, that current research is lacking, and that all stocks in Canadian waters were generally depleted to MSY levels or below, the species is vulnerable and should be considered as rare in Canadian waters. Stocks should only be considered as 'healthy', if, and when, population estimates indicate an increase to 90% of initial population sizes.

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Current Status of the Gray Whale, *Eschrichtius robustus**

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The Gray Whale (*Eschrichtius robustus*) historically inhabited continental-shelf waters of the North Atlantic and North Pacific oceans. The species was extirpated in the North Atlantic, apparently by human hunting, before the end of the nineteenth century. In the North Pacific there are two stocks: west Pacific ("Korean") and east Pacific ("Californian"). Both stocks were exploited by aborigines in ancient times and by commercial whalers in the nineteenth and twentieth centuries. An international agreement in 1937 provided a degree of protection to Gray Whales. However, some hunting of both North Pacific stocks continued. Though the west Pacific stock is now effectively protected from whaling, it presently numbers no more than a few hundred individuals. This stock clearly is endangered. The east Pacific stock is still exploited by the USSR under a quota set by the International Whaling Commission. Gray Whales belonging to the east Pacific stock are also taken occasionally by villagers in Alaska, and some incidental mortality occurs in fishing gear along the west coast of North America. This stock appears to have recovered substantially since the late 1800s and now is thought to contain at least 15 000 whales. In addition to its continuing importance in the "subsistence" of Native peoples, the east Pacific stock has attained considerable importance as an aesthetic and economic resource off western North America. The annual Gray Whale migration to and from winter "nursery" lagoons in Baja California, Mexico, attracts thousands of tourists. In view of the Gray Whale's extirpation in the North Atlantic and its precarious state in the west Pacific, it would seem particularly important to manage the east Pacific stock in a conservative way. It represents the best hope for the continued existence of the mysticete family Eschrichtiidae. Given that the stock continues to be exploited, both directly by whaling and indirectly by net entanglement and vessel collisions, the east Pacific stock should be managed conservatively.

Historiquement la Baleine grise (*Eschrichtius robustus*) habitait les eaux du banc continental des océans nord-Atlantique et nord-Pacifique. L'espèce fut extirpée dans l'Atlantique du nord avant le bout du dix-neuvième siècle, probablement à cause de la chasse. À l'océan nord-Pacifique il y a deux stocks: Pacifique de l'ouest (de la Corée) et Pacifique de l'est (de la Californie). Les deux furent chassés par les autochtones depuis les temps anciens et par les baleiniers aux siècles dix-neuvième et vingtième. Depuis 1937, un accord international leur a fourni une certaine mesure de protection. Cependant, il y avait quelques baleiniers qui continuaient la chasse aux stocks du Pacifique du nord. Bien que le stock du Pacifique de l'ouest soit maintenant protégé contre les baleiniers, aujourd'hui il n'y a plus que quelques centaines d'individus. Ce stock est vraiment menacé. Les baleines du Pacifique de l'est sont encore chassées par les baleiniers de URSS sous un quota établi par la Commission Baleinière Internationale. De temps en temps les Baleines grises du Pacifique de l'est sont prises aussi par les autochtones de l'Alaska, et il y a des morts qui résultent de l'embrouillement avec l'attirail de pêche au côté ouest de l'Amérique du nord. Il semble que ce stock a regagné considérablement ses nombres depuis la fin des 1800's, et aujourd'hui on croit qu'il existe au moins 15 000 baleines. Le stock du Pacifique de l'est a acquis en Amérique de l'ouest une importance considérable comme une ressource économique et esthétique et aussi il garde son importance dans la vie de subsistance des autochtones. La migration annuelle des Baleines grises aux lagunes maternelles à Baja California en hiver, et leur retour printanier au nord attire des milliers de touristes. En vue de l'extirpation de la Baleine grise dans l'Atlantique et sa situation précaire dans le Pacifique de l'ouest, il semblerait être important de gérer le stock du Pacifique de l'est d'une façon conservatrice. Ceci représente le meilleur, et possiblement le seul, moyen d'assurer l'existence de la famille Eschrichtiidae à l'avenir.

Key Words: Gray Whale, *Eschrichtius robustus*, conservation.

The Gray Whale (*Eschrichtius robustus*) is a medium- to large-sized mysticete (baleen) whale (Figure 1). Its known distribution has always been limited to the North Atlantic and North Pacific

oceans. That the Gray Whale is readily distinguished from all other extant mysticetes became apparent from the first illustrations of the skull of this species to be sent to Europe (Beneden 1877).

*Extirpated status approved and assigned by COSEWIC for the North Atlantic stock 7 April 1987. The east Pacific stock which appears in Canadian waters is not in jeopardy in Canada and is not in any COSEWIC category.

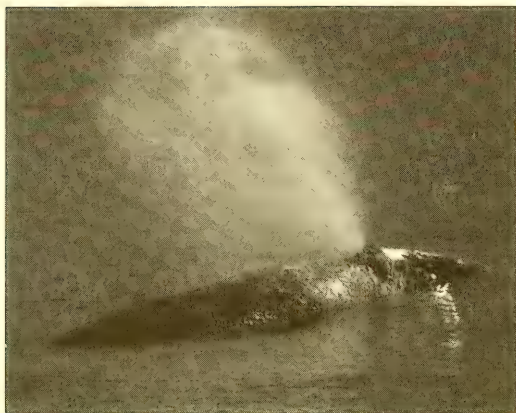


FIGURE 1. A Gray Whale during the southward migration off Point Loma, San Diego, California. Photograph by R. Reeves.

All subsequent work has shown that the Gray Whale has a variety of distinctive characteristics (Barnes and McLeod 1984), which support its assignment to a separate monotypic family, *Eschrichtiidae* Ellerman and Morrison-Scott 1951.

The Committee on the Status of Endangered Wildlife in Canada has requested a review of the Gray Whale's conservation status. Because several geographically distinct stocks of Gray Whales exist (or existed), it is necessary to consider each of these stocks separately. As the species is the sole living representative of its family, there is a particular note of urgency about its preservation.

Distribution and Stock Identity

North Atlantic: The sum of knowledge about Gray Whale distribution in the eastern North Atlantic consists of seven subfossil specimens (listed by Mead and Mitchell 1984: Table 1, Figure 2) and of inferences made from sixteenth- and seventeenth-century documents describing whales found around Iceland and Spitsbergen (Fraser 1970; Mead and Mitchell 1984). From this evidence it can be stated with certainty that the Gray Whale was present in the Baltic and North seas and the English Channel, and probably around Iceland, during post-glacial times. It is unlikely that these areas represent more than a small part of the species' former Northeast Atlantic range, assuming that long-distance seasonal migrations were made there as in the North Pacific at present.

Published records of subfossil specimens of Gray Whales found along the east coast of North America, numbering ten at the time of this writing

(1986), span a somewhat narrower range of latitudes than those from Europe and England. The northernmost is from Long Island, New York (Mead and Mitchell 1984); the southernmost, from St. Lucie Inlet on the southeast coast of Florida (Odell 1983). References in the literature to the "Scrag" Whale (e.g. Dudley 1725) have been interpreted as applying to the Gray Whale (Deinse and Junge 1937; Schevill 1952). The Scrag Whale was known at least from New England waters. Taken as a whole, the evidence suggests that Gray Whales were at one time distributed from at least Massachusetts Bay south to Florida. Odell (1983) speculated that Gray Whales may have bred and given birth in the shallow lagoons and bays of south-central and southeast Florida.

The question of whether there was more than one stock of Gray Whales in the North Atlantic obviously cannot be addressed on such limited evidence. If North Atlantic Gray Whales, like North Pacific Gray Whales, had a coastal distribution and migrated annually between the Arctic and the subtropics, then it is reasonable to speculate that at least two stocks, eastern and western, existed. Gray Whales may have visited Canadian waters, including the Scotian Shelf, Gulf of St. Lawrence, and Grand Banks. If they went further north hugging the coast, they may have entered Hudson Bay and Davis Strait during summer. We would expect them to have followed the coast in a northward migration, returning annually to shallow feeding grounds with high benthic productivity.

North Pacific: Fossil and subfossil records are known from various portions of the Gray Whale's present range in the North Pacific (Omura 1984; Barnes and McLeod 1984). The latter authors described the only Pleistocene specimen apparently of this species (though the ventral surface of the skull was not prepared and described). Barnes and McLeod made the interesting zoogeographic argument that the genus *Eschrichtius* should have a long Tertiary record, but no such record is documented at present. They specifically emphasized (p. 26) the absence of *eschrichtiid* and Gray Whale barnacle (*Cryptolepas*) fossils in the Pliocene San Diego Formation.

If the fossil record of cetaceans is sufficiently complete to allow the use of such negative evidence (and it is not clear that it is), then the absence of fossils of *Eschrichtius* spp. from the San Diego Formation, coupled with the persuasive logic of Henderson (1984: 181–182) for the historic absence of regular winter occurrences of large numbers of Gray Whales in San Diego Bay, might be taken to

demonstrate that the winter inshore distribution of calving whales has remained essentially restricted to the bays or lagoons along the outer coast of Baja California. Such a conclusion would be relevant to arguments about historic changes in environmental carrying capacity.

The general limits of Gray Whale distribution in the North Pacific at present can be described as follows (after Rice and Wolman 1971):

1. In the east from as far south as the Baja California peninsula and lower Gulf of California (Gilmore et al. 1967) to as far north as the Chukchi Sea and, to a limited extent, the Beaufort Sea (Maher 1960; Rugh and Fraker 1981) and East Siberian Sea (Miller et al. 1985). This herd of whales is commonly known as the Californian or east Pacific stock.
2. In the west from as far south as Korea Strait and the Seto Inland Sea (Omura 1974, 1984) to as far north as the Sea of Okhotsk and the coast of Kamchatka Peninsula. This herd is the Korean or west Pacific stock (Andrews 1914). Omura (1984) referred to two different populations, one migrating along the east coast of Japan and possibly calving in the Seto Inland Sea, and the other migrating along the east and south coasts of Korea and the coasts of southwest Honshu and northwest Kyushu. For the present, both groups are considered part of the Korean stock.

One striking aspect of their distribution is that Gray Whales usually do not occur outside the continental shelf. They are coastal animals which congregate near shore and in embayments during winter, follow continental margins during migration, and venture far offshore only while feeding in summer across the broad, shallow shelf of the Bering and Chukchi seas (Pike 1962). Two sightings of Gray Whales made in June 1979 east of Honshu, Japan, in waters 4 000 to 5 000 m deep have been taken as evidence that these whales "can cross the Pacific without keeping to the shallow shelf waters" (Votrogov and Bogoslovskaya 1986). Without more details about these sightings, we remain skeptical of the authors' interpretation of this evidence.

Another important feature of the Gray Whale's distribution is that it encompasses more than 45 degrees of latitude. Thus, the whales winter in waters as warm as 18° to 22°C and summer in waters as cold as 0° to 8°C (Rice and Wolman 1971).

The migration route and schedule of the east Pacific stock have been the subject of detailed investigation and scientific debate (Swartz 1986).

Of particular interest has been the question of whether the whales follow the coast of British Columbia north from Vancouver Island or head diagonally across the Gulf of Alaska toward the eastern Aleutian islands en route to the Bering Sea summering grounds. Pike's (1962) view that the whales "retain contact with the coast while circumscribing the Gulf of Alaska" has generally been upheld by subsequent research. Braham (1984) suggested that the availability of sublittoral food resources is the main reason for the Gray Whale's coastal habit during migration. There is marked segregation in the population during migration, at the winter lagoons, and probably on the summer feeding grounds (Swartz 1986).

Some Gray Whales do not participate in the entire 18 000 km round-trip migration each year (Rice and Wolman 1971; Dohl et al. 1981; Gill and Hall 1983; Braham 1984; Herzing and Mate 1984; Sumich 1985; Blokhin 1986; Swartz 1986). From a Canadian viewpoint, the Gray Whales of particular interest are those that do not migrate to the Bering Sea in summer. Although the migration of whales close along the coast of British Columbia was known for some time (Pike 1962; Pike and MacAskie 1969), it was not until the 1970s that notice appeared in the scientific literature of Gray Whales summering on the coast of Vancouver Island (Hatler and Darling 1974). More recent observations indicate that a few Gray Whales summer along the entire outer coast of Vancouver Island, from Victoria to Cape Scott, and on the mainland coast at least in the vicinity of Calvert Island (Darling 1984). In any one summer, the number of "resident" Gray Whales in British Columbia waters is probably on the order of 35 to 50. In at least one portion of the southwest coast of Vancouver Island (Trevor Channel), the summering Gray Whales forage in nearshore kelp beds, consuming mainly mysids (*Holmesimysis sculpia*) (Murison et al. 1984).

Protection

International

The 1937 International Agreement for the Regulation of Whaling forbade the killing of Gray Whales and "right" whales (balaenids) by signatory states (see Reeves 1984 for more details). Canada acceded to this agreement in 1938. The International Convention for the Regulation of Whaling was established in 1946. Its Schedule restated the ban on commercial taking of Gray Whales but sanctioned taking "when the meat and products of such whales are to be used exclusively for local consumption by the aborigines". It is under this exemption that

"subsistence" whaling for Gray Whales has continued to the present in Alaska and along the Chukotsk Peninsula of the Soviet Union.

With the adoption of new management procedures by the International Whaling Commission (IWC) in 1975, stocks were classified in one of three categories: Initial Management, Sustained Management, or Protection (International Whaling Commission 1976). The west Pacific stock of Gray Whales has been classified as a Protection Stock, with no catching permitted. The east Pacific stock was classified as a Protection Stock until 1978, when it was reclassified as a Sustained Management Stock (International Whaling Commission 1979a: 26). A catch limit of 178 to 179 whales per annum has been set since that time, with the entire catch reserved "to be taken by aborigines or a Contracting Government on behalf of aborigines" for non-commercial purposes. The stable catch level in recent years is thought not to have caused any decline in the stock size (International Whaling Commission 1987).

The Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) of 1973 was ratified by Canada in 1975. Gray Whales were listed under CITES on Appendix I. However, Canada reserved the species on that appendix until 1982 when the reservation was lifted.

National

Mexico: In 1972, the Mexican government declared Laguna Ojo de Liebre and Laguna Guerrero Negro, the nearest major wintering lagoons to southern California, to be refuges for Gray Whales (Brownell 1977; Swartz and Jones 1987). From January 1974, commercial vessels were required to obtain permits before entering Laguna Ojo de Liebre, and even with a permit they were restricted to a single channel near the lagoon inlet (Jones and Swartz 1984). This restriction of access to Laguna Ojo de Liebre resulted in a shift of whale watching to Laguna San Ignacio, some 150 km further south along the outer coast of Baja California. In 1979 the Mexican government made Laguna San Ignacio a Gray Whale refuge and imposed restrictions on whalewatching there. There is now a limit on the number of tourboats that can visit the lagoon at one time and on the number of days a given vessel can remain. Between 15 December and 15 March, all commercial vessel traffic is confined to the lower third of the lagoon. The effect of this restriction is to protect from disturbance an area of the upper lagoon identified as a nursery for mothers and calves (Jones and Swartz 1984; Swartz and Jones 1987).

United States: The Gray Whale has been fully protected in U.S. waters by the Endangered Species Act of 1973 and the Marine Mammal Protection Act of 1972. Under these acts, it is forbidden for Gray Whales to be "taken" by anyone subject to U.S. jurisdiction or in waters under U.S. jurisdiction. To "take" is defined as "to harass, hunt, capture, or kill, or attempt to harass, hunt, capture, or kill". The killing of Gray Whales "for subsistence purposes" by Indians, Aleuts, and Eskimos in Alaska is not illegal, as Native subsistence use is covered by an exemption in both acts. No regulations have been published pertaining specifically to the harassment of Gray Whales.

The National Marine Fisheries Service, the federal agency responsible for protecting whales within U.S. waters, has defined "harassment" in regulations pertaining to Humpback Whales (*Megaptera novaeangliae*) in Hawaii (Anonymous 1979). In these regulations, overflights at altitudes of less than 1 000 feet (*ca* 300 m), boat approaches to within less than 300 yards (*ca* 275 m), changes in vessel speed while close to whales, separation of mothers from calves, and deliberate herding or driving of whales are actions defined as harassment when conducted inside sensitive areas (i.e. calving and breeding grounds).

Canada: Gray Whales are protected in Canada by the Cetacean Protection Regulations, established under the Fisheries Act by P.C. 1982-1790 (SOR/82-614). Licences are required for anyone other than an Indian or an Inuk to hunt cetaceans, including Gray Whales. To "hunt" is defined in the regulations as "to chase, shoot at, harpoon, take, kill, attempt to take or kill, or to harass cetaceans in any manner". Indians and Inuit are allowed to hunt whales (other than balaenids) without a licence, as long as the whales are used for "local consumption". Whalewatching "guidelines" have been published by the Department of Fisheries and Oceans (Breton 1986).

Exploitation

North Atlantic Stock(s): There is no direct evidence that the North Atlantic Gray Whale population was hunted. However, Mitchell (1973) speculated that it was "exterminated by human activity" and that "long-term and intensive hunting accounted for the last few animals." The early literature summarized by Fraser (1970) and Mead and Mitchell (1984) suggests that whalers were familiar with the Gray Whale and its product yields.



FIGURE 2. Gray Whales were among the species taken in the Japanese coastal harpoon and net fisheries which began in the sixteenth and seventeenth centuries, respectively. The wood block print (above) features Humpback Whales (far left) and Right Whales (*Eubalaena glacialis*; far right) but also what is probably meant to be a Gray Whale amongst the Humpbacks. The scroll painting of a Gray Whale (below) dates from the early Kambun period (1661-1673). The scroll is believed to be the oldest extant scroll on the subject of whales and whaling in Japan. Courtesy of Kendall Whaling Museum, No. 515 of their *Prints* (1969) volume (above); from Hashiura (1969) by permission of National Institute of Japanese Literature (below).



FIGURE 3. Gray Whales were hunted for subsistence by the Makah Indians at Neah Bay, Washington, into the early twentieth century. Photograph by Asahel Curtis, 1910, courtesy of University of Washington, Northwest Coast Collection.

West Pacific Stock: There is a sparse record of aboriginal whaling in the Sea of Okhotsk, but it seems very likely that Gray Whales were hunted by the ancient inhabitants of its shores (Krupnik 1984). Gray Whales were a part of the catch in Japan in the extensive harpoon fishery begun by the sixteenth century (Figure 2) and the net fishery begun in the second half of the seventeenth century (Omura 1974, 1984). Large numbers of Gray Whales were also caught in the Sea of Okhotsk, north of 53°N, by American pelagic whalers, whose main target was the Bowhead Whale (*Balaena mysticetus*), beginning in the late 1840s (Henderson 1984: 176–177). This fishery declined by the 1880s.

Modern (Norwegian) whaling began on the coast of Korea in about 1903, and by 1933 the catch of Gray Whales had declined to a very low level (Andrews 1914; Mizue 1951). Although single Gray Whales killed off the northern Kurile Islands in 1942 and off the southeast coast of Honshu in 1959 and 1968 have been considered as possible “strays” from the east Pacific stock (Mizue 1951; Nishiwaki and Kasuya 1970; Bowen 1974), we agree with Brownell and Chun (1977) that these whales more likely belonged to the much-reduced west Pacific stock. No direct exploitation of west

Pacific Gray Whales is known to occur at present (see Brownell and Chun 1977 and Brownell 1981 regarding recent Korean whaling). The killing of Gray Whales by fishermen when the whales are found near fishing gear may go largely unnoticed (see Nishiwaki and Kasuya 1970; Ivashin 1986).

East Pacific Stock: There is a long history of aboriginal whaling for baleen whales, including Gray Whales, from as far south on the American coast as the present-day state of Washington, across the Aleutian islands, and on both sides of the Bering and Chukchi seas (Rice and Wolman 1971; Mitchell 1979; Ivashin and Mineev 1981; Krupnik et al. 1983; Chlenov and Krupnik 1984; Krupnik 1984, 1987; O’Leary 1984). Such whaling continued, with some changes in technology, until 1928 (Figure 3) on the coast of Washington (Rice and Wolman 1971: 120) and until the 1960s and early 1970s in Chukotka (Krupnik et al. 1983; Krupnik 1987).

Commercial whaling for Gray Whales was conducted from shore stations along the North American coast (Rice and Wolman 1971; Sayers 1984; Nesheim n.d.) [Figure 4] and in the Mexican lagoons and offshore by American nineteenth-century pelagic whalers (Scammon 1874; Hender-

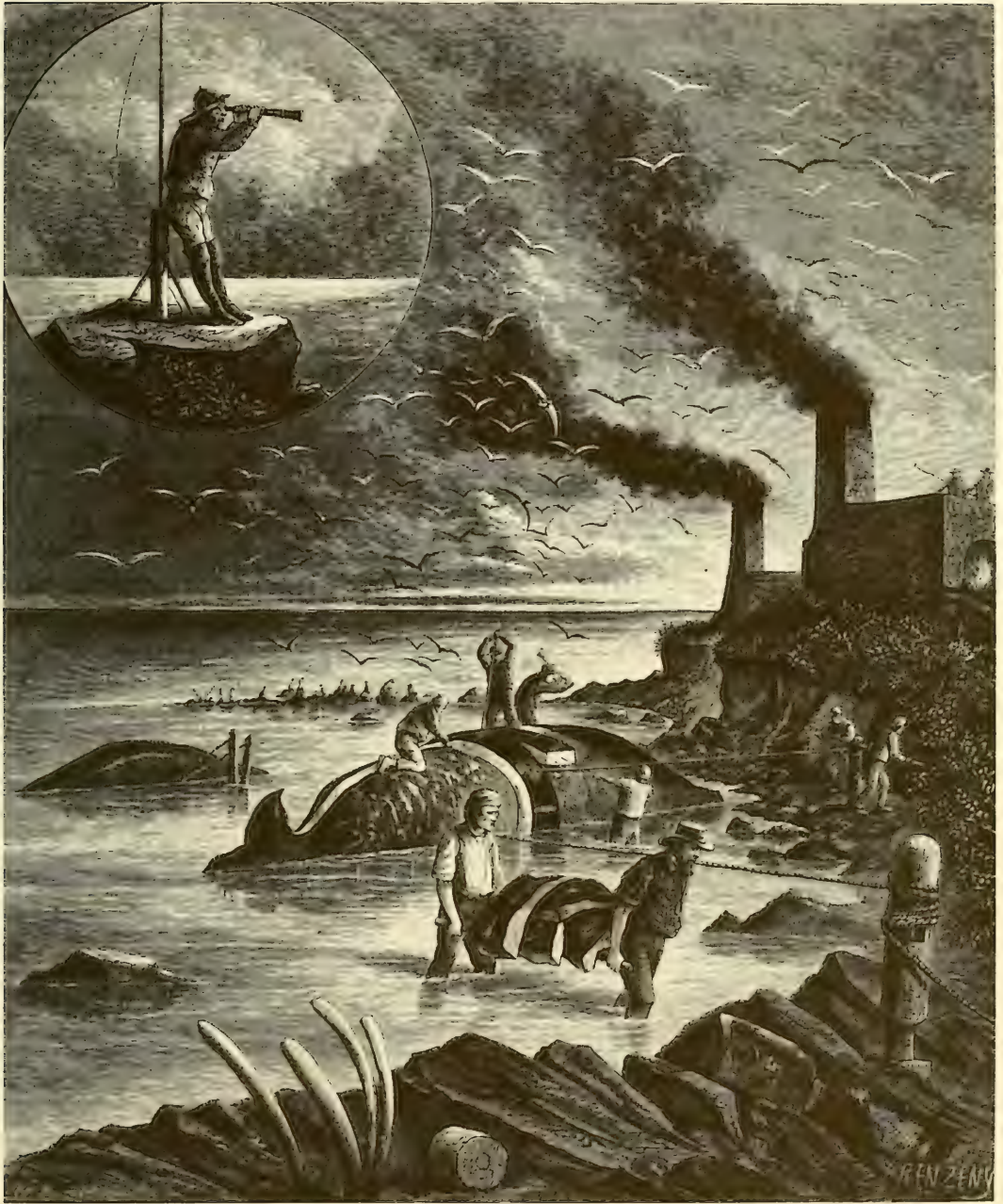


FIGURE 4. An uncolored wood engraving from the cover of *Harper's Weekly, A Journal of Civilization*, 23 June 1877, Vol. XXI, No. 1069, showing a whaling station on the coast of California. According to the article on page 483 of the magazine, "the whale most commonly taken" at such stations was the "gray-back", or Gray Whale, although the engraving is not sufficiently detailed to judge whether the whale pictured is intended to be a Gray Whale.

son 1972, 1984). In addition, about 1 000 Gray Whales were taken by modern floating factories from Norway, the USSR, and Japan in the twentieth century (Reeves 1984). A catch of Gray Whales was made by the U.S. and Canada (Figure 5) during 1953–1970 under special scientific permits (Pike 1962; Rice and Wolman 1971).

In recent years, the direct exploitation of Gray Whales from the east Pacific stock has been limited to the catch of 150 to 200 made each summer by a modern Soviet catcher boat and delivered to villages along the Chukotsk Peninsula (Ivashin and Mineev 1981; Krupnik et al. 1983; Krupnik 1987) and a few more (less than 10 in most years) by the native people of Alaska, mainly at St. Lawrence Island, Wainwright and Barrow (Marquette and Braham 1982). Gray Whales in Alaska are usually killed with high-powered rifles (Maher 1960: 263). In the Soviet fishery most of the carcasses are delivered to the villages of Lorino, Uelen, Novoe Chaplino, Sireniki, Yanrakinnot, and Uelkal (Krupnik 1987). According to the IWC Schedule of Whaling Regulations, the products of these hunts are to be used only for the local consumption of aboriginal peoples. According to Krupnik (1987) Gray Whales brought ashore at Chukotka are used as follows: Part of the meat and skin (with blubber) is distributed among the inhabitants; portions of skin and gum are also consumed during the processing. The meat of stranded Gray Whales is sometimes used as fox bait and dog food. (See Special Significance section.)

Entanglement in fishing gear is an indirect form of exploitation that affects the east Pacific stock. Between November 1980 and June 1985, 33 Gray Whales were reported as entangled in gillnets between San Francisco and San Diego, California; 19 of the whales are known to have died (International Whaling Commission 1986: 102; *also see* Heinonen 1985; Talbot 1985). Gill-net entanglement has been a problem for Gray Whales migrating along the California coast since at least the 1950s (Norris and Prescott 1961: 360–361), but the recent increase in the use of synthetic fibers for netting probably has made it more difficult for the whales so entangled to break free. There is also at least one documented record of a Gray Whale calf being entangled in a fishing net in Laguna Ojo de Liebre (Withrow 1983: Figure 8).

Collisions of Gray Whales with powered vessels have been documented on the U.S. west coast (Patten et al. 1980). Some of these collisions have caused the whale's death. In other instances, the whale has survived but in mutilated condition (*also see* Gilmore 1959).

Abundance

Atlantic Stock(s): Gray Whales are extinct in the North Atlantic, and there is no information on the size of the population(s) that formerly existed there.

West Pacific Stock: The west Pacific stock is severely depleted. Considering the magnitude of known removals by hunting during historic times, there must have been several thousand whales in this stock before it was exploited. The population in 1910 has been estimated as about 1 000 to 1 500 (Rice and Wolman 1971).

It was assumed that by the 1930s the west Pacific stock had been virtually exterminated (Mizue 1951; Rice and Wolman 1971: 122; Bowen 1974). However, at least 67 Gray Whales were taken in Korean waters from 1948 to 1966 (Brownell and Chun 1977), and recent observations in the Sea of Okhotsk, near the Kurile Islands, in the Sea of Japan, and off the Pacific coast of Japan demonstrate that Gray Whales still occupy parts of the stock's historic range (Furuta 1984; Blokhin et al. 1985; Votrogov and Bogoslovskaya 1986). Some authors have dismissed recent sightings in the west Pacific as involving "strays" from the east Pacific (Nishiwaki and Kasuya 1970; Bowen 1974). It seems to us unlikely that such straying could account for all of the sightings recorded to date, but the point remains moot until some biochemical or other means of distinguishing between individuals of the two populations is tested and used to resolve this question.

As many as 20 Gray Whales, of various sizes, have been seen recently during summer and autumn near the north end of Sakhalin Island in the Sea of Okhotsk (Blokhin et al. 1985; Berzin et al. 1986; *also see* Votrogov and Bogoslovskaya 1986). Soviet investigators have interpreted these sightings as evidence not only of the west Pacific stock's continued existence but of its slow recovery. The number of Gray Whales surviving is probably in the tens or low hundreds.

East Pacific Stock: Charles M. Scammon (1874: 23), a literate and successful whaling captain (Landauer 1982), estimated that no more than 10 800 Gray Whales were killed off western North America between 1846 and the early 1870s. He guessed that the "initial" population (in 1853 to 1856) "did not exceed 40,000 — probably not over 30,000". Scammon supposed that no more than 8 000 to 10 000 California Gray Whales survived by 1874. From a detailed reconstruction of the catch history, Henderson (1972: 185) estimated that the population size in 1845 was about 15 000

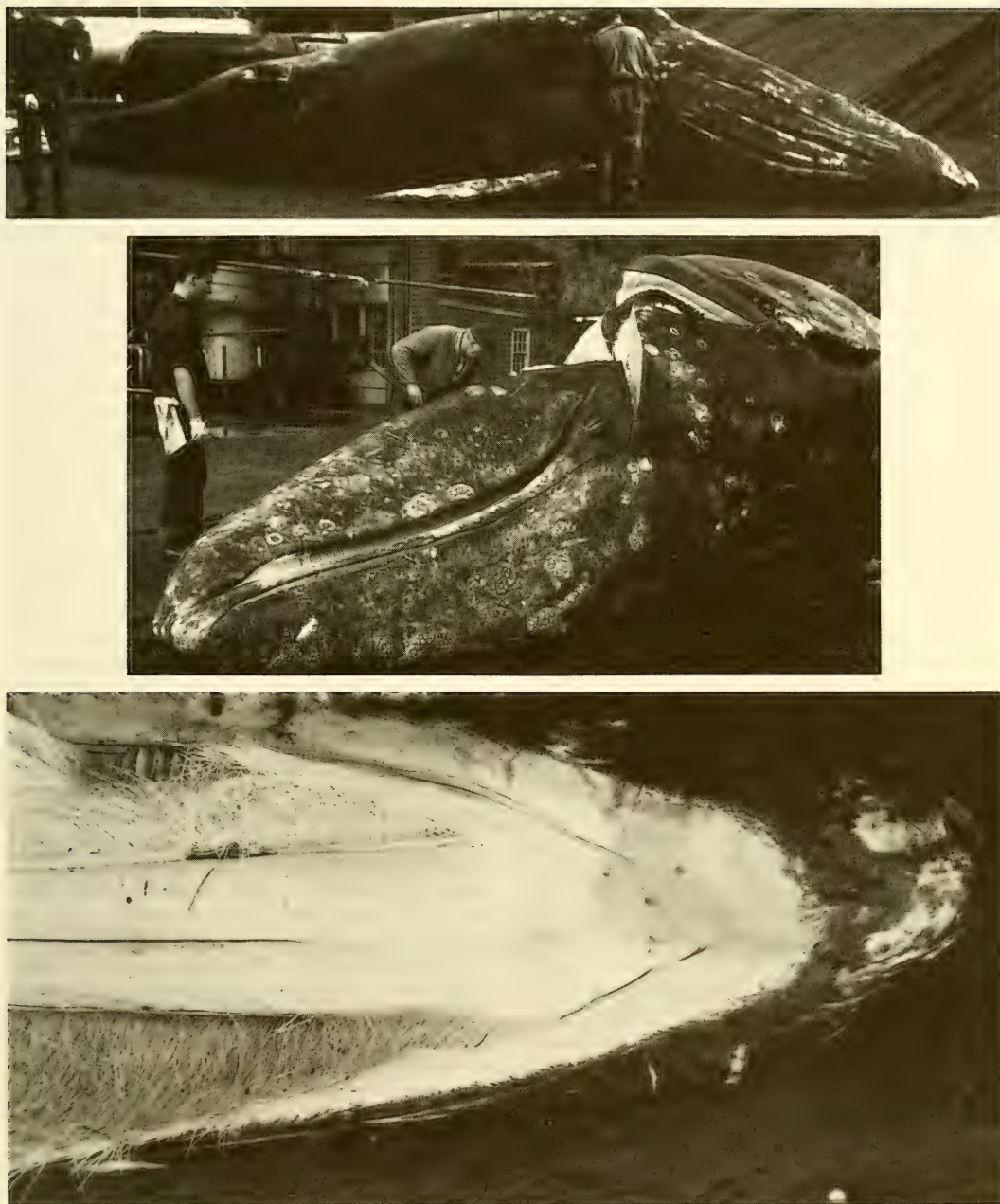


FIGURE 5. Ten Gray Whales were taken at the Coal Harbour, British Columbia, whaling station in April 1953, under a special government permit (Pike and MacAskie 1969). Note the three prominent gular grooves, the large flippers, and the protuberant uro-genital area (top). The slightly open mouth shows the light-coloured baleen plates and the route followed by filtered water as it escapes from the mouth (middle). The two sides of baleen do not meet at the front of the mouth, as they do in balaenopterids (bottom). This creates an opening into the mouth cavity which allows the skim-feeding whale to sample continuously a horizontal column of water as it swims with the mouth slightly open. Note too that Jacobsen's organs lie within the functional buccal cavity, unlike in the Balaenopteridae in which they lie anterior to it. Photographs from Gordon C. Pike files.

to 20 000. Ohsumi (1976) estimated historical population trends, assuming a current, stable population level of about 11 000 and that the rate of removals by aboriginal hunters was a constant 1.5 percent per year since before 1846 and until 1975. Ohsumi used the commercial kill records provided by Henderson (1972), Townsend (1887), and Rice and Wolman (1971) in his model, and he concluded that by 1846, when commercial whaling began, the east Pacific stock had been reduced by aboriginal whaling to about 11 600 whales, compared to a carrying-capacity level "somewhat larger than 15,000." According to Ohsumi's model, the population reached a low of 4 400 in 1875, with recovery to 11 000 and "stability" in the early 1960s. Ohsumi believed the current carrying capacity to be less than that of the past but on what basis is unclear. By his calculations, the current stock of 11 000 was 74 percent of the present carrying-capacity level of 14 900, and 30 percent above the maximum sustainable yield level (estimated as 57 percent of the potential virginial level). Mitchell (1979) showed that Ohsumi's estimates of removals by aborigines were too low, resulting in an underestimation of initial population size. [Note that O'Leary's (1984: 99) statement that Mitchell (1979) "assumes that the aboriginal take was all gray whales" is in error.] Mitchell (1979) also questioned the validity of Ohsumi's assumption of a decrease in carrying capacity from the mid 1880s to recent times.

Reilly (1981) simulated the population history over the period 1800 to 1980, using various combinations of biological parameters, aboriginal kill rates, and pre-exploitation (carrying capacity) population sizes. The values producing a trajectory which fit most closely the expected behaviour of the population during this time were 24 000 whales for carrying capacity, reduced to 12 000 whales in 1800 due to a substantial aboriginal removal rate of 600 per year.

From an age-structured population model Lankester and Beddington (1986) estimated a minimum pre-exploitation (1845) population of 10 000 and a maximum of about 25 000. The application of a deterministic population trajectory model, using known catch records and with built-in density dependence of the kind currently applied in the IWC, consistently indicates a population decrease in the period 1967 to 1980 (Lankester and Beddington 1986). This is not supported by estimates from censuses (below). Thus, either the Lankester-Beddington model is intrinsically flawed, the catch record they used is grossly incomplete or inaccurate, the carrying

capacity has increased since 1845, or the population did not begin its recovery from a depleted state until much later than is generally assumed.

There is no doubt that by the 1870s and 1880s the stock was depleted, but to what extent is unclear. Shore counts of Gray Whales were made in California beginning in the early 1950s (*see* Reilly et al. 1980 for a summary). Gray Whales have also been censused from shore as they funnel through Unimak Pass, in the eastern Aleutian islands, during the southward fall migration (Rugh 1984). Aerial counts of Gray Whales in the Mexican lagoons during winter were first attempted in 1952 and have been conducted periodically since then (*see* Reilly 1984: Table 1, for a summary). The Unimak Pass counts made in three successive years (1977 to 1979) resulted in a conservative best estimate of about 17 000 Gray Whales (Rugh 1984). The California shore counts have given similar results. Based on 13 consecutive years of California shore census data, Reilly et al. (1983) estimated the population in 1980 as 15 647. From these data, they also concluded that the population had been increasing over the period 1967 to 1979 at an exponential net rate of about 2.5 percent per annum. Though Cooke (1986) challenged this conclusion, Reilly's (1987) reanalysis confirmed that a net upward trend, on the order of 0.5 to 4.0 percent per annum, had occurred.

Estimates of current population size from shore censuses have taken account of observer biases and impaired visibility. However, the most serious shortcoming of shore censuses has been the lack of reliable information on night travel rates (Reilly 1981, 1984). It has been assumed that the whales maintain a constant rate of movement past the shore censusing stations over a 24-hour period, and raw counts have been extrapolated accordingly to make the population estimates. Eighteen Gray Whales were radio-tagged and tracked off California during the shore census in January 1986 (Swartz et al. 1987). No statistically significant change in swimming rate between night and day was noted, so the assumption behind previous extrapolations appears justified.

After a lapse of four years, a full (60-day) census was made near Monterey in December 1985–February 1986, with the following important results (Breiwick and Dahlheim 1986): (a) Since the late 1970s the migration route in the vicinity of Monterey may have shifted farther offshore (*see also* Dohl and Guess 1979); (b) Given (a) above, and the fact that even experienced and well-trained teams of observers fail to detect some fraction of

the whales passing the census site (Rugh et al. 1986), earlier estimates of population size based on shore counts probably are underestimates of absolute abundance.

The problem of reconciling winter aerial counts with shore counts during migration remains. Rice et al. (1981, 1983 *as cited in* Reilly 1984) made the most recent systematic aerial counts at the winter grounds in Mexico. They estimated 7 601 adults and 1 439 calves from their 1981 census. Because of differences in methodology, these estimates could not be compared with previous aerial estimates. Reilly (1984) pointed out that the implied crude birth rate from Rice et al.'s estimates (0.19) is unrealistically high. According to Swartz (1986), there are probably many more Gray Whales outside the breeding lagoons during winter than had been assumed previously. Also, it is likely that substantial numbers of whales are missed in aerial surveys, for a variety of reasons listed by Reilly (1984). Thus, winter aerial surveys probably lead to gross underestimates of absolute Gray Whale abundance.

Given the severe problems affecting estimates made on the calving grounds (Reilly 1984), resources should be applied preferentially to shore censuses during migration rather than to aerial censuses on the wintering grounds. A high priority for improving the reliability of future Monterey shore censuses is to study the offshore distribution of whales during the censusing period, using aerial and/or shipboard observations.

Habitat

As a species which passes close to industrially developed coastlines during its annual migration, the Gray Whale is exposed to a variety of pollutants. Strandings of Gray Whales following an oil spill in Santa Barbara Channel, California, in January 1969 prompted reports in the media that the whales had died from the effects of crude oil (Orr 1969). It is interesting that in the same area, whalers working out of Goleta during the 1860s supposedly abandoned the station "because [naturally-occurring] petroleum floating in the ocean 'frightened the whales away' and badly gummed the whale-lines" (McGrew 1922 *in* Nesheim n.d.: 31). Brownell (1971) found no evidence that the number of strandings was exceptional in 1969 or that oil contamination of any kind caused any of the Gray Whale deaths.

There is experimental evidence that migrating Gray Whales react to a variety of acoustic stimuli, including noise from marine geophysical exploration air gun systems as well as taped playbacks of

sounds associated with oil or gas exploration or development operations (Malme et al. 1983). In experiments conducted off California, the whales gave "annoyance" and "startle" responses and changed their speed and course when subjected to playbacks. Air gun activity caused the whales to slow down, turn away from the source, and increase their respiration rates.

The quality of the Gray Whale's Mexican wintering grounds is of particular concern. Some of the lagoons formerly used "have probably been so modified by man that they are no longer available, and the ultimate stable level of the [east Pacific] population could therefore be now below that in the past" (Allen 1980: 94; and *see* Ohsumi 1976; Mitchell 1979). A variety of activities have been conducted over the past century and a half at Laguna Ojo de Liebre, an important calving or nursery lagoon. Guano and *orchilla* (raw material of red and violet dyestuffs) collection, turtle fishing, and gold mining have taken place in and along the shores of this lagoon (White and Matthews 1956; Henderson 1972). The most important activity has been salt mining. Extensive saltworks were developed in the inner lagoon during the 1950s and 1960s, and salt continues to be an important export from this area. At present, there is only one major channel within Laguna Ojo de Liebre which is not frequented by whales, and this is transited several times a day by salt barges. There is no conclusive evidence that Gray Whales formerly used this area, but "it seems likely that the whales have learned to avoid" it (Withrow 1983). Canal de Ballenitas is a former nursery area that has been diked and is now used as a pumping station and salt evaporation pond. Salt production and dredging in Laguna Guerrero Negro, a small lagoon just north of Laguna Ojo de Liebre, is thought to have caused Gray Whales to desert this lagoon during the 1960s (Gard 1974). With the re-routing of salt traffic since 1967, Laguna Guerrero Negro has been re-occupied by Gray Whales (Bryant et al. 1984). It has been claimed that San Diego Bay in southern California was a Gray Whale calving ground or nursery, and that whales are now excluded from it by human disturbance (e.g. Gilmore 1960). However, Henderson (1984: 181-182) convincingly argued against the popular belief that this bay was ever a significant part of the winter range of Gray Whales.

An unusually large number of Gray Whales was sighted in the southern Strait of Georgia (British Columbia) and Puget Sound (Washington) in spring and early summer 1984 (Anonymous 1984). Eight whales were found dead, and their deaths

were linked in the media to various toxic substances, including pesticides, PCBs, heavy metals, and wood preservatives (Knox 1985). However, no conclusive evidence has been published linking the whales' deaths to the effects of pollutants.

Life History

Age and Growth: The ear plugs of Gray Whales, when longitudinally bisected, reveal growth layers assumed to be deposited annually (Rice and Wolman 1971; Blokhin and Tiupleyev 1987). Because the laminae laid down in the earliest years of life may "disappear" in mature whales (Rice and Wolman 1971: 39–40), readings from ear plugs may underestimate absolute age. Adult females can be aged more reliably by reference to corpora in the ovaries.

Asymptotic lengths were estimated at 12.97 m for females ($n = 68$) and 12.43 m for males ($n = 100$) (Rice and Wolman 1971). Maximal length in females is about 15 m; in males, about 14.3 m. Gray Whales continue growing until about 40 years of age. One male specimen examined by Rice and Wolman (1971) had 70 growth layers in the ear plugs. As would be expected, the major growth spurt occurs during the first year, when calves grow from a birth length of about 4.6 m to about 7 m at the time of weaning in August and 8 m by one year of age (Sumich 1986).

The mean age at sexual maturity is 8 years (Rice and Wolman 1971) or 6 to 7 years (Blokhin and Tiupleyev 1987) for both sexes.

Reproduction: The Gray Whale is the only mysticete for which good specimen material is available representing the early embryonic phase and the perinatal period (Rice 1983). Although sexual behaviour by Gray Whales has been observed year-round, the period of conception is

well defined on the basis of the condition of ovaries and the length distribution of fetuses. The mean date of conception has been calculated as 5 December (Rice and Wolman 1971). Thus, the peak of effective mating occurs in late November and early December, while the whales are still en route to the Mexican "breeding" lagoons. Courtship in and near the lagoons is intensive, i.e. the abundance of courting whales is high, from the end of December through the second week of February (Swartz 1986). The median date of parturition has been calculated as 27 January on the basis of calf counts in Laguna Ojo de Liebre (Rice et al. 1981; *also see* Jones and Swartz 1985). The mean date of five observed Gray Whale births was 21 January (Rice 1983). Rice (1983) revised the estimated gestation period from about 13 months [400 days] (Rice and Wolman 1971) to 418 days, or closer to 14 months. There appears to be a period of arrested growth during the last month of fetal development, which Rice called the prenatal diapause.

Most adult females give birth to a single calf in alternate years (Jones and Swartz 1985). Only one instance of twin fetuses has been reported (Blokhin 1987).

Mortality: The rate of calf mortality in and just outside the Mexican wintering lagoons has been estimated as 5.4 percent, based on the number of dead calves observed (Swartz and Jones 1983). Pooled data on strandings in Laguna San Ignacio, Laguna Guerrero Negro, Laguna Ojo de Liebre, and Boca de Soledad between 1954 and 1983 demonstrated that calves are much more susceptible to fatal stranding in the lagoons than are adults (calves averaged 91.4 percent of total dead whales vs. an adult proportion ranging from 0 to 5 percent) and that yearling mortality is also



FIGURE 6. A young 8.2-m male Gray Whale which stranded at Wreck Bay, Vancouver Island, in August 1966 (*see* Pike and MacAskie 1969: 31, 33, for additional data on the specimen). Photograph from Gordon C. Pike files.

higher than adult mortality (yearlings constituting from 0 to 19.5 percent of the strandings) (Jones and Swartz 1984). A separate study of stranding patterns suggested that nearly 75 percent of first-year mortality occurs within a few weeks of birth, in the wintering lagoons, and that juvenile mortality is concentrated in the first two year-classes (Sumich and Harvey 1986) [Figure 6].

In addition to the strandings in lagoons, some calves die during the northward migration as a result of shark or Killer Whale (*Orcinus orca*) predation, or of becoming lost, disoriented, and separated from their mothers before weaning (Swartz and Jones 1983). Numerous attacks on Gray Whales by Killer Whales have been observed (Rice and Wolman 1971; Ljungblad and Moore 1983; Ivashin 1986).

The overall annual adult mortality rate is between 0.08 and 0.10 for both sexes (Rice and Wolman 1971).

Feeding: On their northern summer feeding grounds Gray Whales are stenophagic consumers of benthic amphipods (Rice and Wolman 1971; Nerini 1984; Wuersig et al. 1986). There is a marked change in nutritive condition between whales en route to their winter grounds in late fall and those en route to their summer grounds in spring (Rice and Wolman 1971). To a considerable extent, Gray Whales appear to fast in winter and feast in summer. However, increasingly there is evidence of opportunism in the Gray Whale's diet and feeding behavior. Southward-migrating Gray Whales have been seen preying on "small bait fish" in January off Monterey, California (Sund 1975). Based on the stomach contents of birds killed while feeding with a Gray Whale along the Alaska Peninsula in September, Gill and Hall (1983) inferred that the whale was feeding on an epibenthic Sand Shrimp (*Crangon septemspinosa*). Observations of a small (ca 6 m) Gray Whale mouthing kelp off Santa Barbara, California, in April were interpreted as evidence of attempts to catch quantities of the small kelp mysid *Acanthomysis sculpta* (Wellington and Anderson 1978; also see Cochrane 1981). The question of whether, or how extensively, Gray Whales feed in and near their Mexican wintering grounds has been mooted for some time (e.g. Gardner 1963; Gilmore 1968; Rice and Wolman 1971; Walker 1971; Norris et al. 1983; Swartz and Jones 1987). There is good circumstantial evidence (reviewed by Norris et al. 1983) that they do some feeding there, probably mainly on Red Crabs (*Pleuroncodes planipes*) and the euphausiid *Nyctiphanes simplex*. However, the bottoms of calving lagoons show no

evidence of Gray Whale feeding excavations; nor do these lagoons appear to have bottom communities of invertebrates suitable for extensive feeding by Gray Whales (Oliver et al. 1983b; Swartz and Jones 1987).

The waters near Bamfield Marine Station on the west coast of Vancouver Island have provided researchers with opportunities to study Gray Whale feeding behaviour through both surface (Murison et al. 1984) and underwater observations (Oliver et al. 1984; Guerrero 1985; Hudnall 1985; Plewes et al. 1985). Mysids are an important prey, but the whales also feed on dense ampeliscid amphipod communities in this area.

Because they arrive much later than other whales, females with calves spend only about 3.5 months on the northern feeding grounds; whereas, newly pregnant females spend nearly twice as long (6.9 months) in high latitudes (Swartz 1986). Though the ranges of Gray Whales and Bowheads overlap to some degree in the northeast Chukchi Sea, the two species are essentially allopatric there, with the Gray Whales arriving after the Bowheads have migrated east into the Beaufort Sea and departing for the Bering Sea before the Bowheads return on their westward autumn migration (Moore et al. 1986).

Special Significance of the Species

Ecological: As pointed out by Kanwisher and Ridgway (1983), whales probably play a significant role in lifting nutrients upward in the water column, as they are forced to approach the surface regularly for air. "Even the whales' fecal output does not move downward: because it is liquid, it tends to disperse rather than sink when it is released." As almost exclusively benthic feeders, Gray Whales probably play as important a role in the gross nutrient dynamics of their environment as any large marine predator could (cf. Oliver and Slattery 1985). Their energetic demands, estimated on the basis of a population of 15 500 whales foraging for 3 to 5 months in summer, might require them to turn over 3 565 km² of sea bottom per year, or about 9 percent of the available amphipod community in the Bering Sea (Nerini 1984). Gray Whales use suction in feeding (Ray and Schevill 1974), and consequently they excavate depressions in the sea floor (Nerini 1984; Swartz and Jones 1987). In an area closely studied off the west coast of Vancouver Island, Oliver et al. (1984) noted:

"Gray whales remove a large volume of sediment and infauna from each excavation, and produce a large valley within a dense tube mat of

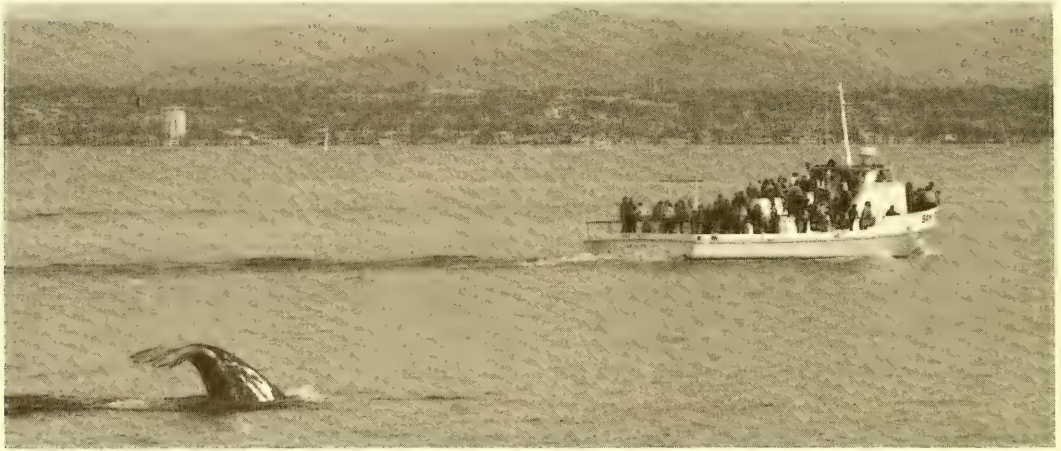


FIGURE 7. Gray Whales are observed by thousands of tourists each year as they migrate along the west coast of North America. They are watched from headlands on shore as well as from boats and aircraft. Photograph by R. Reeves, off San Diego.

amphipod crustaceans. These valleys provide open space, trap suspended and drifting particles, and undoubtedly attract particular groups of colonizing species".

This interaction of Gray Whales with the benthic invertebrate community implies a close indirect connection between Gray Whales and other vertebrates which depend on the benthos for food (see Oliver and Slattery 1985). For example, by disturbing the sediment, Gray Whales might increase production of several species of amphipod crustacean, which in turn decrease the recruitment of young bivalves (through predation, injuring, etc.). In this way, Gray Whale foraging could reduce the availability of bivalves as food for Walrus (*Odobenus rosmarus*) and other clam predators (Oliver et al. 1983a).

Economic (Whalewatching): Rice (1961) stated: "In managing the gray whale, its commercial value should be regarded as secondary to its esthetic value". Already by the early 1960s, large numbers of tourists were watching the Gray Whale migration, both from land and from sportfishing boats offering special excursions to whalewatchers. The first excursion boat entered Laguna Ojo de Liebre (Scammon's Lagoon) in 1970, and by 1973 approximately 30 trips were made to this lagoon during the winter whalewatching season (Gard 1974). This traffic was superimposed upon the activities of salt barges, trailered boats, and private yachts. Many naturalists voiced concern about the impact of tourist traffic and industrial activity on the east

Pacific stock of Gray Whales (American Society of Mammalogists 1971, 1972; see Reeves 1977 for a summary), and some measures have been taken to protect the whales and their habitat from such disturbances (see Protection).

Long-term studies of lagoon utilization patterns and the effects of whalewatching were initiated at Laguna San Ignacio in 1978 (Jones and Swartz 1984; Swartz and Jones 1987). No significant changes in the whales' use of this lagoon have been detected. At least since 1975, some Gray Whales in Laguna San Ignacio have approached boats in a curious or friendly manner, giving thousands of tourists an opportunity to touch or pet these wild whales.

Whalewatching in California (Figure 7) has considerable economic significance, with estimates of gross income of \$2 187 000 in 1981 (Kaza 1982) and \$2 600 000 in 1984 (Tilt 1985).

Economic (Subsistence): The rationale for making the take of Gray Whales by Native peoples exempt from the moratoria imposed by the International Convention for the Regulation of Whaling, the U.S. Marine Mammal Protection Act, and the U.S. Endangered Species Act is that such taking contributes to subsistence. Marquette (1979) stated that "although the muktuk of the gray is thinner and less desirable than that of the bowhead, the meat from this [the gray] whale is highly prized for food" on St. Lawrence Island. Rice and Wolman (1971: 121) stated that the whale catch at Gambell was "almost entirely gray whales". However, the reported landed catch of

Gray Whales on St. Lawrence Island (Gambell and Savoonga) from 1965 to 1980 was 12 (Marquette and Braham 1982), while the reported Bowhead catch during the same period was 36 (Braham et al. 1979; Braham et al. 1980; Marquette and Bockstoce 1980; Johnson et al. 1981). Although more Gray Whales have been taken in recent years at Gambell than at any other village in Alaska, "Eskimos here do not regularly hunt gray whales, but rather take them opportunistically only after the late spring-early summer walrus (*Odobenus rosmarus*) hunting season" (Marquette and Braham 1982). Marquette and Braham found "no evidence to suggest that gray whales are at present of any particular interest to the Eskimos". The Gray Whale apparently plays a negligible or minor role in the present-day subsistence of Alaskan Native peoples.

At the 1983 meeting of the International Whaling Commission, concern was expressed in the Aboriginal/Subsistence Whaling Subcommittee of the Technical Committee about the legitimacy of the USSR's claim that the Gray Whale catch off Chukotka is for "subsistence" (see Rinehart and Dawson 1983). The USSR responded by noting the difficulty of collecting information on Gray Whale utilization from the seven to nine "dispersed settlements along the coast at which gray whales are landed" (International Whaling Commission 1984: 21). The representative of the USSR assured the group that efforts were being made to "increase the output of products for human consumption from the carcasses". Papers submitted to the sub-committee the following year included information "on the variety of foodstuffs consumed by the aboriginal population in the Chukot Region" (International Whaling Commission 1985: 18). Krupnik (1987) supplied some information on the processing and utilization of Gray Whales at Chukotka in recent years.

Evaluation

The Atlantic stock of Gray Whales is extirpated, and the only option for "managing" it is to reintroduce whales from the North Pacific in the hope of establishing a North Atlantic population. At present, this option might be considered impractical, although the technology and competence exist for capturing and transporting cetaceans the size of young Gray Whales over great distances. A Gray Whale ("Gigi") was captured alive as a newborn in 1971 and released into the wild a year later (Evans 1974; Coerr and Evans 1980). It is also relevant to note that adult Killer

Whales are transported regularly over long distances by marine parks, and these animals are as large (to 9 m and 8 tons) as young Gray Whales (Wolman [1985: 69] reported the size of two immature Gray Whales taken on their northbound migration as 9.25 and 9.90 m and 8808 and 8876 kg, respectively).

The west Pacific stock is endangered, as its present abundance is far below the pre-exploitation level. However, with no rigorous estimate of either initial or current population size, it is impossible to estimate what percentage of initial stock size the current population represents. Full protection is warranted for an indefinite period. A potential means of enhancing this stock might be to reduce the catch of Gray Whales off Chukotka. There is some chance that by thus allowing full recovery (to the "initial" stock size or the present carrying capacity) of the east Pacific stock, emigration or "bleeding" from that stock into the west would occur or increase. This could be envisioned as an experiment on a grand scale, but some means would need to be found for confirming that the current population in the west Pacific is not already a result of such migratory "bleeding". It is unlikely that a large sample of skulls and skeletons for morphometric comparisons will become available from the whales presently occupying the Okhotsk Sea stock's range. Thus, approaches other than the conventional comparison of hard parts will be needed to establish whether these whales differ appreciably from whales in the east Pacific stock. Fujino (1960) has demonstrated with other mysticetes the utility of blood-group comparisons to evaluate stock relationships at this level. We recommend that serological (or other tissue) studies be attempted, for example, using tissue from freshly stranded carcasses, tissue obtained with a biopsy dart, or tissue obtained from whales that are temporarily restrained (accidentally in fishing gear or intentionally by some live-capture technique).

The east Pacific stock should not be classified as endangered. It has recovered substantially from depletion by whaling. If Reilly et al.'s (1983) estimate of stock size in 1980 (15 647 whales) is taken as the best estimate available, and Reilly's (1981) estimate of 24 000 is used for the maximum equilibrium population level, then the current stock size is in the order of 60 to 65 percent of initial. Since many decisions by the IWC about stock classification are built upon the premise that the maximum sustainable yield (MSY) level occurs in mysticetes at or near 60 percent of initial, it could be argued that the east Pacific stock is at or

above the MSY level. The IWC Scientific Committee's Sub-Committee on Protected Stocks noted in 1978 that if Ohsumi's (1976) model is accepted [current population at 74 percent of "potential virginal level" — *but see* Mitchell (1979), Reilly (1981), and Lankester and Beddington (1986)], this stock should be classified as an Initial Management Stock with a quota of 50 males and zero females in addition to the Soviet "aboriginal" catch of 150 to 200 per year (International Whaling Commission 1979b: 84). The Scientific Committee, however, recommended (International Whaling Commission 1979b: 49), and the Commission agreed (International Whaling Commission 1979a: 26), on its classification as a Sustained Management Stock (which assumes the stock to be at a level of 54 to 72 percent of initial), with a catch limit of 178 whales, reserved for the use of aborigines. Thus, direct exploitation is at present limited by an internationally-agreed quota which is believed to be set below MSY. Compliance with the quota appears to be good. No IWC member has formally announced any intention to resume commercial whaling for this species.

Additional modeling is needed to understand trends in population size for the east Pacific stock. A more detailed reconstruction of catch history than is presently available, particularly for the years after about 1874, would be useful for future attempts at modeling the population. The compilation by Sayers (1984), based principally on newspaper records and other printed sources (including some cited by Nesheim n.d.), provides a "fragmentary" accounting of Gray Whale catches from shore stations. Much additional effort is needed to fill in the years for which no catch is currently documented, to convert production statistics into whales landed, to estimate loss rates, and to prorate catches of unspecified "whales" so that the Gray Whale component can be determined*. Also, the more precise listing of the removals from the stock by year (*cf.* Henderson 1972: Table 1; 1984: Table 1) might allow examination of the short-term impacts of large kills on the population.

A decision against listing the east Pacific stock as threatened or endangered presupposes that: (1) there will be no increase in the direct harvest by the USSR, by North American aborigines or by others; (2) there will be no further deleterious

modification by man of the population's critical winter and summer habitats; (3) regulation of tourism (whalewatching) will continue in the present manner or, if anything, become more strict; and (4) incidental mortality caused by fishing gear will not increase. If, at any future time, any of these conditions is no longer met, the stock's conservation status should be re-considered. The stock should be managed conservatively, given that it is still hunted on its summer feeding grounds and that industrial activity is increasing in many parts of its range. However, it is our opinion that the east Pacific stock of the Gray Whale does not fit in any presently-recognized COSEWIC category.

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- 1916: 187; Howell and Huey 1930). However, Townsend (1887) believed the stock was "in no immediate danger of extermination" in the mid 1880s, in spite of continued coastal whaling. Recent modelers generally have upheld Townsend's view. The following portion of a letter from Victor H. Street of Aberdeen, Washington, to Roy Chapman Andrews of the American Museum of Natural History (AMNH) in New York, dated 5 December 1913 (examined in the Department of Mammalogy of the AMNH), is relevant to questions about the east Pacific stock's abundance in the early 1900s:
- Regarding the Cal. Gray Whale . . . they are very plentiful all along the Washington Coast in the spring. They even work as far north as Sechart B.C. The Station at Grays Harbor [Washington, *see* Scheffer and Slipp (1948)] catch about 6 each year — not because that is all they can get but because they could get nothing else at the time & they did not want to come in (the boats) without anything. I am informed that they get a few each year at Sechart and possibly Kyuquot B.C. The California Grays are small & yield between 7 and 12 bbls of oil only, so you will understand that they are not very desirable. The gunners report schools of a hundred or more seen along the coast near Gray's Harbor, but usually there are no other variety [of whales] seen at the same time.
- The Blubber oil is light pink and the meat oil is deep orange in color. They are covered with vermin, far more so than humpbacks, and their barnacles are of the flat variety, very deeply imbedded in the blubber. The whale lice often cover completely a patch a yard square, as close together as they can get, often looking from a short distance as if the blubber was chafed. The Gillbone (baleen) . . . is cream white throughout, and is square on the outside edge, and quite thick. It is used I believe for making bristles for 'whale bone hair brushes'.
- We do not keep the oil separate but put it in with our second & third quality. There may be a difference in the quality of the oil from the Humpback & Fin but as we always mix it we cannot tell. I don't know how far South they are seen, but I have heard that they are plentiful at some seasons near the Santa Barbara Channel in Cal.
- Scheffer and Slipp (1948: Table 1) listed only one Gray Whale as delivered to the Bay City whaling station between 1911 and 1925, though they noted (p. 310) that Street, manager of the station in 1911 and 1912, had told them of a few having been taken during those years. Scheffer and Slipp further suggested that Gray Whales may have been lumped with Humpback Whales in the whaling statistics. Except for a few years at Kyuquot, the British Columbia whaling statistics from 1905 to 1918 are not broken down to species (Pike and McAskie 1969: Appendix I). Judging by Street's statement quoted above, it is likely that some Gray Whales were included in the British Columbia catch during those years.

Note

It has been alleged that the east Pacific stock of Gray Whales was severely depleted, perhaps near extirpation, at around the turn of the twentieth century (e.g. Andrews

The unspecified or unrecorded catches of Gray Whales off Washington and British Columbia exemplify the need for a more exhaustive review of the east Pacific stock's catch history. Lankester and Beddington's (1986: 357) appendix, entitled "The Maximum Recorded Kill of Gray Whales from the East Pacific Stock", shows a catch of "zero" for 1893 to 1912, followed by one in 1913, 19 in 1914 and "zero" in 1915 to 1917. A more thorough search

of archival and other documents than has been made to date would give these authors and other modelers a better basis for assessing population trends through the critical period of the late 1800s and early 1900s. It is particularly important to attempt to disentangle the Gray Whale catches from the Humpback Whale catches.

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Status of the Narwhal, *Monodon monoceros*, in Canada*

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The Narwhal, *Monodon monoceros*, ranges throughout the eastern portion of the Canadian Arctic. Major summering areas are well defined but migration routes are not completely known. Recent estimates indicate the mean estimate of Narwhals in Canadian waters during summer is 18 800. Comparison of these results with previous estimates show no decline in numbers. Narwhal distribution appears to be directly influenced by ice conditions and food availability. Marine fish, decapod crustaceans and molluscs are important prey species for Narwhals. Limiting factors are not well defined, but hunting has the potential for limiting the populations under current conditions. It is recommended that the Narwhal not be placed in any category (NIAC) at this time, but that its status be reviewed periodically as new data becomes available.

Le Narval, *Monodon monoceros*, habite la partie est de l'Arctique canadien. Les principaux quartiers d'été de cette espèce sont bien délimités, mais on manque d'information sur les voies de migration qu'elle emprunte. Selon des estimations récentes, il y aurait au moins 18 800 Narvals dans les eaux canadiennes en été. La comparaison de ces chiffres avec des estimations antérieures indique que la population n'a pas diminué. La distribution des Narvals semble dépendre directement de l'état des glaces et de l'accessibilité de la nourriture. Les poissons marins, les Décapodes Crustacés et les Mollusques sont d'importantes proies pour l'espèce. Les facteurs limitatifs sont mal connus mais, dans les conditions actuelles, la chasse aurait limité la croissance des populations. Nous recommandons que le Narval ne soit classé dans aucune catégorie, mais que sa situation soit révisée à mesure qu'on obtiendra de nouvelles données.

Key Words: Narwhal, *Monodon monoceros*, cetaceans, rare and endangered species, marine mammals, arctic mammals.

Narwhals, *Monodon monoceros*, are medium sized odontocetes without a dorsal fin (Figure 1). Young animals are dark bluish grey in color, with white blotches appearing on the ventral surface and flanks as they mature. Adult animals become almost completely white ventrally with black and white mottling on the sides, grading to black dorsally. Narwhals have two teeth embedded horizontally in the maxilla, one on each side. The left tooth, and occasionally the right, of the male erupts into a sinistrally spiraled tusk which rarely exceeds 2 m in exposed length and 10 kg in weight. Tusked females, tuskless males, and double tusked males occur rarely.

Adult males may reach a length of 4.7 m and a weight of 1 600 kg, females are smaller reaching 4 m in length and 900 kg in weight (Mansfield et al. 1975). Maximum lengths recorded during a harvest study (1982-83) in Pond Inlet, Northwest Territories (NWT) were 4.86 m and 4.20 m respectively for males and females (Weaver and Walker 1988). Calves are 1.5-1.7 m at birth (Best and Fisher 1974); Hay (1984) reported a mean

birth length of 1.61 m, and a weight of about 80 kg (Mansfield et al. 1975). Tomilin (1957) reported maximum lengths of 6 m and 5 m for males and females in Soviet waters respectively.

Distribution

Narwhals are seldom seen south of 65°N, but stray animals have been recorded from the coast of Norway, Ireland, the Netherlands, Britain, and in the Gulf of St. Lawrence (Fraser 1949; Aquayo 1978; Reeves and Mitchell 1981). They occur in Baffin Bay and Davis Strait, the waters east of Greenland (Pederson 1969), around Spitsbergen (Herbert 1969), Franz Josef Land and the Eurasian Arctic (Tomilin 1957). Occasional records of occurrences in the Beaufort Sea and Amundsen Gulf may be strays from other areas (Smith 1977; Mitchell and Reeves 1981). Current distribution appears little changed from historical reports and it is unlikely that the animals of the eastern Canadian Arctic have any significant contact with those of east Greenland and Eurasia (Mitchell and Reeves 1981).

*Status reviewed by COSEWIC in April 1986 and again in April 1987 and found not to be in any COSEWIC category (NIAC).

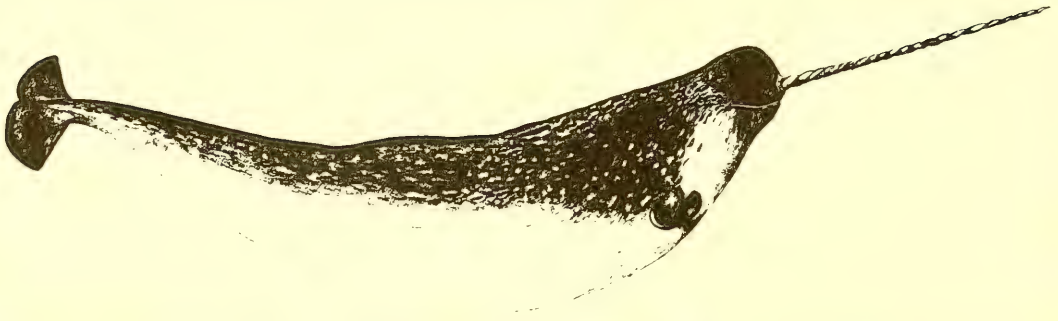


FIGURE 1. Male Narwhal, *Monodon monoceros*, with tusk (Drawing by J.-C. Campet; courtesy Department of Fisheries and Oceans).

Three stocks of Narwhals (one summering in northwest Greenland, one in the Canadian High Arctic, and one in northwestern Hudson Bay) have tentatively been recognized for management purposes by the Department of Fisheries and Oceans (DFO), Central and Arctic Region, within the overall aggregation that winters in Davis Strait/Baffin Bay. It is not clear, however, if these stocks are unique entities exhibiting breeding and site fidelity or if there is interchange of individuals or groups. The best known stock is that of the High Arctic which occurs in the waters and deep fiords of Baffin Bay, between western Greenland and Baffin Island, and throughout the eastern Canadian Arctic Archipelago (Mansfield et al. 1975). Known summer concentrations (Figure 2) occur in Eclipse Sound, Admiralty Inlet, Prince Regent Inlet, and Peel Sound. Lancaster Sound appears to be a major travel route to and from summer concentration areas rather than a summering area.

The northwestern Hudson Bay stock occurs in the vicinity of Repulse Bay in Foxe Channel and near southern Southampton Island. The affiliation of Narwhals occurring in northern Foxe Basin is unclear, although an apparent gap in distribution between Hall Beach and Foxe Channel suggests they are part of the High Arctic stock. Narwhals have been observed wintering in the pack ice of Baffin Bay, Davis Strait (McLaren and Davis 1983), and the Disko Bay area of West Greenland (Vibe 1967; Kapel 1975, 1977). Small numbers may winter in Hudson Strait (MacLaren and Marex Inc. 1979a, 1979b; McLaren and Davis 1981; Finley and Renaud 1980).

The range and distribution of the Narwhal may be directly related to long-term temperature fluctuations and the resultant ice cover (Vibe 1967).

Protection

Narwhal management in Canada is conducted by the Department of Fisheries and Oceans (DFO) under the authority of The Fisheries Act and the Narwhal Protection Regulations, which provide for protection of habitat, management of the species, and control of the harvest. The Narwhal Protection Regulations, which limit hunting to Inuit, specify annual community quotas and general regulations dealing with use, harassment and hunter limitations. Narwhal quotas were originally derived through negotiation with Narwhal hunting communities based on historic harvest levels and limited biological data. The quotas are updated as population data become available.

Domestic trade in Narwhal parts or derivatives (including tusks) is controlled by a tag system under the Narwhal Protection Regulations and export from the Northwest Territories is controlled by export permit. International trade is controlled through the Convention on International Trade in Endangered Species (CITES) permit system. The Canadian Wildlife Service (Canadian CITES administrative authority) reports an average export of 62 Narwhal tusks per year from Canada since 1979, when this species was first listed on CITES Appendix II.

There are additional conservation strategies that are supported by DFO which are relevant to Narwhal management and protection. Canada has officially endorsed the World Conservation Strategy (WCS) to: *i*) maintain essential ecological processes and life support systems, *ii*) preserve genetic diversity, and *iii*) ensure the sustainable utilization of species and ecosystems. A Task Force on Northern Conservation was established in 1983 to report to the Minister of Indian Affairs

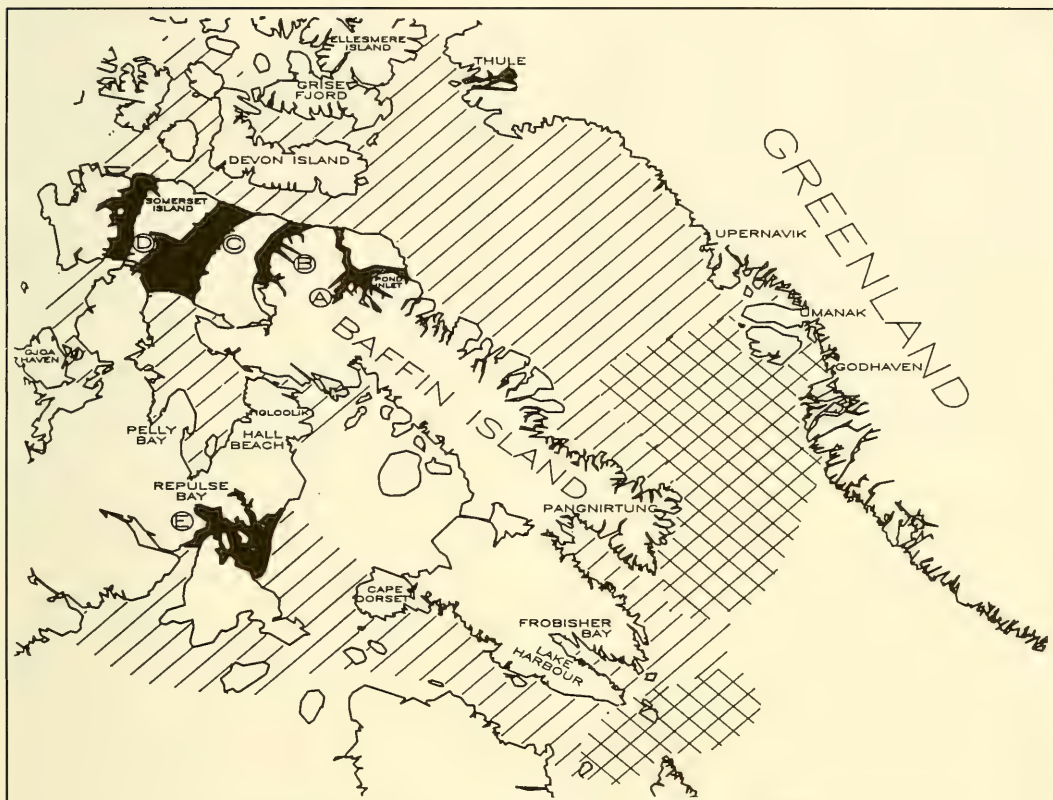


FIGURE 2. Distribution of Narwhal in Canada. Modified from Kemper (1980) to include material from literature cited and unpublished material from L. Dueck, P. Richard and J. T. Strong.

- | | |
|------------------------------------|------------------------|
| A — Eclipse Sound/Navy Board Inlet | /// Known Range |
| B — Admiralty Inlet | ● Summer Concentration |
| C — Peel Sound | ▧ Known Winter Range |
| D — Prince Regent Inlet | |
| E — Foxe Channel | |

and Northern Development and the governments of the Northwest and Yukon Territories. Northern land use planning and settlement of native land claims should assist in establishing sound conservation principles in the Northwest Territories.

Population Size and Trends

Historic population levels of Narwhals in the Canadian High Arctic stock are uncertain. Davis et al. (1978) estimated that 20 000 to 30 000 Narwhals passed through Lancaster Sound in 1976, based on extrapolations from the land based survey of Greendale and Brousseau-Greendale (1976) and the aerial survey of Johnson et al. (1976). This estimate was supported by Koski

(1980). Smith et al. (1985) estimated that 13 200 to 18 000 Narwhals summer in the Lancaster Sound area based on aerial surveys conducted between 1974 and 1982, although their surveys did not cover the entire summer range of Narwhals in the area. Small groups of undetermined size were known to exist in northern Hudson Bay and Foxe Basin (Mansfield et al. 1975).

During the summers of 1983, 1984, and 1985, distribution and abundance surveys of Narwhals covering Eclipse Sound, Admiralty Inlet, Prince Regent Inlet and Peel Sound (Figure 2) were undertaken as a joint enterprise between the Canadian Department of Fisheries and Oceans (DFO) and World Wildlife Fund of Canada (WWFC). During August 1984, aerial photogra-

phic surveys produced an estimate of 17 900 Narwhals (uncorrected for submerged animals) in the survey area (J. T. Strong, unpublished; L. Dueck, unpublished). Similar surveys were conducted by DFO in the Repulse Bay area during the summers of 1983 and 1984, concomittant with the High Arctic surveys. Analysis revealed an estimate of 1 400 Narwhal (uncorrected for submerged animals) in the survey area (P. Richard, unpublished). Smaller numbers of Narwhals occur in northern Foxe Basin and other areas scattered through the Arctic Archipelago at this time. Thus, the uncorrected mean estimate of the number of Narwhals present in known concentration areas during summer is 19 300.

These estimates for Narwhals summering in Canadian waters do not include animals summering in The Thule Melville Bay area of Greenland which were estimated roughly at 2 500 by F. Bruemmer [1971. Notes on sea mammals, Thule District, Greenland. Unpublished manuscript] and which have since been surveyed by E. Born (personal communication) who made a direct count of 4 000 animals in 1985.

There is no recent evidence which suggests a Narwhal population decline although historical perspective does not permit rigorous comparison of surveys. Current photographic aerial survey estimates are similar to or higher than estimates from the earlier visual aerial surveys of Johnson et al. (1976), Davis et al. (1978) and McLaren and Davis (1981, 1983). Tuck (1957) and Greendale and Brousseau-Greendale (1976), twenty years apart, estimated similar numbers of Narwhal (ca. 6 000) migrating through Lancaster Sound in early summer from land based surveys. Fallis et al. (1983) reported an estimate of 9 700 Narwhals in Admiralty Inlet during a July 1975 aerial survey. DFO/WWF 1984 results estimated approximately 6 000 Narwhals in August. Estimates from the hunting communities of Canada and Eastern Greenland, which harvest Narwhals from the High Arctic and Northwest Greenland stocks, have not indicated any decline in Narwhal population during this century (Mitchell and Reeves 1981), although both technology and hunting effort has changed during the same period.

Habitat

Narwhals are normally found in deep coastal waters in contrast to Belugas, *Delphinapterus leucas*, which frequent shallows and river estuaries. Little is known of the specific habitat requirements of Narwhals, but they seem to be influenced by at least two major factors: *i*) ice conditions, and *ii*) the availability of food (Larsen 1984).

Vibe (1967) refers to the importance of sea ice distribution in the Narwhal's range and points out that when the Greenland current penetrates further north, Narwhals remain at higher latitudes for slightly longer periods during autumn and winter. In spring Narwhals from the High Arctic stock move from their wintering area, suggested by Vibe (1967) to be an "ice edge" ecological niche, towards the Canadian coast in the vicinity of Lancaster Sound. As soon as ice conditions permit, Narwhals penetrate westward to their summering areas in the sounds, inlets and channels adjacent to Lancaster Sound.

Results of aerial surveys (McLaren and Davis 1981) indicate that Narwhals are extremely wide spread in southern Baffin Bay and northern Davis Strait during winter (Figure 2). Although Narwhals are present in the loose pack ice off the west coast of Greenland, their centre of abundance appears to be more to the northwest in the close pack ice. Strong movements of Narwhals to the north and northwest were noted in the pack ice north of 70°N in March, suggesting that some migration might have been underway. In May, Narwhals were observed widely distributed in the close pack ice of Baffin Bay as far north as the latitude of Lancaster Sound.

In June and July as the fast ice begins to break, Narwhals move westward to their summering areas feeding intensively as they go. Arctic Cod *Boreogadus saida*, Greenland Halibut, *Reinhardtius hippoglossoides*, Squid *Gonatus fabricii*, decapod crustaceans, molluscs and sculpins (Cottidae) have been reported as primary food species for Narwhals (Mansfield et al. 1975; Silverman 1979; Best 1981; Finley and Gibb 1982). Finley and Gibb (1982) found deepwater fish such as Redfish, *Sebastes marinus*, Polar Cod, *Arctogadus glacialis*, and halibut primarily in the stomachs of male Narwhal although both sexes were sampled. They also found that little feeding took place during late summer. Arctic Cod, Greenland Halibut and crustaceans have also been mentioned as primary food species for Narwhals in Greenland waters (Vibe 1967; Born 1983; as cited by Larsen 1984). Cephalopod molluscs and fish were the primary food species of Narwhals taken in Russian waters (Tomilin 1957). Composition of Narwhal diet during winter months is unknown.

General Biology

Reproductive Capability: Hay (1984) provides the most recent information on the life history of Narwhals. His conclusions are summarized here. Male Narwhal, which mature sexually at body

lengths exceeding 3.9 m and at 16-17 growth layers (of hard tissue laid down in the teeth or jaw), display protracted maturation and may have an annual cycle of spermatogenesis. Females, mature sexually at lengths exceeding 3.4 m and 12 growth layers, and are seasonally polyoestrous, experiencing up to four consecutive ovulations during the breeding season. The gestation period is estimated to be 15.3 months, with conception occurring during March to May and calving occurring during July and August of the following year. The interval between successive conceptions is usually three years, but about 20% of females conceive at the first breeding season following birth of their calf. The annual population birth rate is calculated to be about 0.07.

Hay suggested Narwhals may live for up to 50 years or more if one growth layer is laid down each year. Recent discussions of ageing suggest that two growth layers are laid down each year (Brodie 1982; Goren et al. 1987) and longevity is likely 25-30 years.

Species Movement: Narwhals are social animals frequently observed in small groups or pods. Unlike the Beluga they do not normally congregate in large herds (Mansfield 1983), although large numbers may be found together during annual migrations.

The migration routes of Narwhals are not completely known but north and northwest movements have been observed in Baffin Bay as early as March (McLaren and Davis 1983). Animals often appear to follow the retreating ice edge up the west coast of Greenland to Melville Bay and the North Water off Thule (Davis et al. 1980). From there some continue north into Smith Sound but the majority turn west to Lancaster Sound by June or July (Johnson et al. 1976). The autumn migration begins in September or October, but is not well understood (Davis et al. 1980). There may be a regular southerly fall movement along the east coast of Baffin Island.

Greendale and Brousseau-Greendale (1976) noted that during the westward migration of Narwhals past Cape Hay, northern Bylot Island, tusked animals tended to occur in larger groups and pass earlier in the migration. Neonates were first observed on June 26, and groups of females with calves predominated later in the migration. These observations suggest that sexual segregation is a feature of Narwhal migration.

Behaviour and Adaptability: The most conspicuous feature of the male is an elongated upper tooth or tusk. Silverman and Dunbar (1980)

speculated that the tusk is used in aggressive behaviour and others (Mansfield et al. 1975; Best 1981; Reeves and Mitchell 1981) postulated on the use of the tusk to poke breathing holes in the ice, for foraging, or as a focussing mechanism for echolocation signals used in navigation and food location. No theory has been widely accepted, and the question of tusk use remains unanswered, particularly as few females are tusked.

Narwhals, although well adapted to an existence in ice-covered seas, sometimes become trapped by accumulation of ice in early winter, particularly in shallows or bays. In these entrapments (known as "savssats") Narwhals keep breathing holes open by breaking fresh ice up to 5-6 cm thick, but they may perish if the ice becomes thicker and they are unable to maintain a large enough breathing hole, or escape to more open conditions.

Limiting Factors

The natural variation in the numbers and distribution of Narwhals, particularly on the periphery of their range is such that determination of habitat loss would be difficult without specific long term studies. There is no available data which suggests habitat loss has affected Narwhal numbers or distribution.

Lancaster Sound is the only feasible shipping route in the eastern Arctic and will be of major importance if oil and gas exploration produces workable wells. There is, therefore, potential for disturbance and perhaps loss of habitat, although the question of environmental disturbance on the Arctic trophic web is of such magnitude that reliable predictions are unlikely in the near future.

The effect that industrial activity might have on Narwhals is of concern. Narwhals would be susceptible to ship noise when migrating, and during winter when they are in the heavy pack ice of Baffin Bay and Davis Strait (Mansfield 1983). Narwhals in the vicinity of ice breakers in the entrance to Admiralty Inlet moved slowly away from the track of the ship and remained silent along the ice edge (Finley and Davis 1984). However, Finley and Davis (1984) also point out that in view of the accommodation that Belugas have shown to ship traffic in other areas and because the Belugas also exhibited flight behaviour, the Admiralty Inlet response may have been due to "naivety". Brodie (1984) stated that tolerance may reflect habitat priority. Assessment of disturbance should therefore be made with care.

Concentrations of heavy metals and organochlorides in marine mammals are being investigated as a possible threat (Smith and Armstrong 1978;

Wagemann and Muir 1985; Wagemann et al. 1983, 1984). Heavy metals have been detected in Narwhal tissues collected from northern Baffin Island, but no source could be established (Wagemann et al. 1983). High mercury levels reported from other marine mammals have not been linked to industrial activity (Sergeant 1980; Smith and Armstrong 1975, 1978). Accumulations of some metals, cadmium for example, increase with the age of an animal suggesting they are not easily metabolized (Wagemann et al. 1983) and possibly accounting for relatively high levels in some animals. Pollution is now world wide, but whether it will become a limiting factor for Narwhals is still unknown.

Reliable estimates of natural mortality are not available. The only natural predators of Narwhals are Killer Whales, *Orcinus orca*, and possibly, Polar Bears, *Ursus maritimus*. The harassment and predation of Narwhals by Killer Whales has been recorded based on Inuit reports (see Freuchen 1935 and Freuchen and Salomonsen 1958) and eyewitness accounts (Steltner et al. 1984; R. Campbell, personal communication) near Pond Inlet, NWT. No information is available on parasitic or pathogenic organisms which may be limiting to the species.

Currently, hunting has the greatest potential as a limiting factor for Narwhals. The average yearly removal from the two Canadian and the northwest Greenland Narwhal stocks, including an estimate of animals struck but lost based on Weaver and Waller (1988) and Kapel (1977), is approximately 492 (Canada), and 390 (Greenland), totalling 882 animals. Clearly, unregulated, inefficient hunting could limit the numbers of Narwhals found in Canadian waters. The current total harvest is 63% of minimum estimated calf production (7% of 20 000 = 1 400 calves) for the two Canadian stocks, which should be maintaining their numbers at the very least although natural mortality is still unknown.

Special Significance of the Species

Narwhals are one of only three species of Arctic whales, and their status has become a matter of international importance. The annual hunt for Narwhals is an ongoing, traditional activity of Inuit in the eastern Canadian Arctic, but it has been suggested that the sale of ivory rather than the need for food forms the basis of the modern hunt (Land 1976; Kemper 1980). In 1983, the European Economic Community (EEC) banned the importation of Narwhal products from all countries except Greenland, based on a belief that international

trade in ivory could have a detrimental effect on Narwhal numbers (EEC Regulation No. 3626/82). In May 1985 at the biennial meeting of CITES a proposal to move Narwhals from CITES Appendix II to CITES Appendix I and thus ban the importation of Narwhal products in all countries signatory to the convention, was narrowly defeated.

The International Whaling Commission (IWC) is expected to suggest international guidelines for management of some small cetaceans, including Narwhals.

Evaluation

Based on DFO/WWF 1984 aerial surveys, the current estimate of Narwhals in the four High Arctic concentration areas is 17 900, with a further 1 400 in the Repulse Bay area. These estimates are similar to estimates from earlier surveys suggesting that the Narwhal population may be stable. However, a historical perspective does not permit any rigorous comparison of surveys.

Data from recent surveys suggest that a minimum of 1 400 calves are born annually in Canada. Harvest data from the past ten years, including a kill/loss ratio determined from hunt observations, indicates an annual removal of 492 Narwhals by Canadian hunters. Current data suggests that the Narwhal population of Canada is stable and can sustain the current level of harvest. It is recommended that Narwhals not be given any special status at this time, but that its status be reviewed periodically as new data becomes available.

Acknowledgments

Thanks to R. Campbell, P. Richard, R. Stewart, P. Weaver and three anonymous reviewers for their suggestions, critiques and input, all of which assisted in creating a better report. Thanks also to C. Catt and B. Cohen for technical assistance, and to P. Richard and L. Dueck for permitting references to their unpublished data. Thanks are due to E. Born (Greenland Fisheries and Environmental Research Institute) for communications on Narwhals in the Thule District of Greenland and to R. Campbell (Department of Fisheries and Oceans) for communications on predation on Narwhals by Killer Whales.

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Book Reviews

ZOOLOGY

The Bird Watcher's Diary

By Edgar M. Reilly and Gorton Carruth. 1986. Fitzhenry and Whiteside, Toronto. 218 pp., illus. \$12.95.

This book is apparently aimed primarily at the beginner birder. It sets out to supply answers to the questions most frequently asked about birds, and to give insights into some of the broader issues in ornithology, all in a diary format which allows the topics to be introduced as they become timely through passage of the year.

Each week some aspect of birdlife is discussed in a short essay, usually of between one and three pages in length. These are copiously illustrated by vignettes in the margins and scattered through the text, and supplemented by marginal notes. Where appropriate tables are introduced summarizing such things as bird box dimensions for various species, or food preferences. Each weekly section concludes with a page for the owner's notes, and a couple of small blocks, one suggesting activities supposedly appropriate to the week in question, and the second, titled "Comings and Goings", highlighting some aspect of bird distribution in North America. The book concludes with a check list (with space for entries) of North American birds, and a short index. The range of topics covered is indeed extensive, ranging from Bird Feeders to Evolution and from Field Trips to Bird Art.

The concept of the book is an appealing one and I approached it in a positive frame of mind, an attitude that gave way to irritation as I progressed through it. It's a book that badly needs editing, and the multitude of silly mistakes reduces the reviewing process to one of systematic nit-picking.

Nomenclature is one problem, with inconsistencies in English names throughout the text. We find

Upland Plover, Old Squaw Duck and Duck Hawk together with the currently accepted names for these species. Another is ambiguity and inaccuracy: Greater Shearwaters are not most easily seen in winter, not all fish-eating birds have serrated bills, and Jabirus and Ruddy Ground Doves are little more than accidentals in south-east Texas. The sketches are not immune: one pigeon silhouette looks vaguely like a blackbird (another is excellent), and the Long-billed Curlews look like godwits to me. I counted 27 slips of this kind in 35 pages before giving up the quest.

At a more basic level the book just tries to undertake too much. There is insufficient space provided for the diary to be very useful as a diary, and the text tries to cover so much ground that it becomes plodding and lapses into oversimplifications leading to the kind of errors noted above. The enormous geographical area covered makes it very difficult to make timely suggestions that apply to the entire continent. For Canadians the activities proposed are sometimes too late and sometimes too early, and Canadian material generally is poorly researched. For example, the authors seem unaware of *Nature Canada*, but offer this journal as a *Natural History Magazine* instead!

This is an attractive little book with a great deal of interesting information, but its flaws could seriously confuse a beginner birder, and a more experienced observer will be able to turn to more comprehensive — and accurate — sources of information.

CLIVE E. GOODWIN

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A Field Guide to the Birds of Hawaii and the Tropical Pacific

By H. D. Pratt, P. L. Bruner, and D. G. Berret. 1987. Princeton University Press, Princeton, New Jersey. xx + 409 pp., illus. Cloth U.S. \$50; paper U.S. \$19.95.

My first instinct with any new field guide is to look at the colour plates. Are the birds lifelike in shape and posture? Are the colours and patterns of the plumage accurate? Do they have artistic merit? These characteristics can be evaluated rapidly and are important as bird watching is a very visual exercise. *Birds of Hawaii and the Tropical Pacific* scores a very resounding "yes" to all the above questions. In fact, I soon found myself wondering if this wasn't the *best* illustrated field guide I had seen. So I gave the plates a more detailed review and still came away impressed. It is possible to be picky on some small details but I do not think this is worthwhile. In fact I have only one real complaint. Some of the individual portraits are a bit small. Larger reproductions would have been more enjoyable (but not necessarily more useful). I would like to see H. Douglas Pratt's originals someday.

The supporting text is typical of the better field guides: important characteristics of habitat, habit, voice, etc., are briefly but succinctly highlighted. Again I have checked for detail in the difficult-to-separate species and the information given is current and accurate. I found a few areas where minor, but useful points have not been included (the shape of the eye-stripe on Sharp-tailed Sandpipers or the two-toned bill of the Nordmann's Greenshank; and the Sandgrouse calls are poorly described). But again, these are minor points. Very rare birds are mentioned briefly in the main text, but the reader is expected to refer to other field guides for full details. It is unlikely that a vacationer will need the extra references but a resident would be wise to buy a North American, a Japanese, and an Australian guide.

Preceding the species accounts there is the typical introductory section on how to use the book. More useful for the visitor is a general description of the tropical Pacific with specific

information on habitats. The book also includes an excellent innovation. At the end of the bird plates there are 12 photographs of plants that are important to birds. It's a little annoying to have the pictures so far from the text but the authors deserve credit for their inclusion. Part of this chapter concerns conservation issues. It is a most depressing section, detailing a variety of problems and containing a three page table of endangered (or possibly extinct) birds. The human propensity for destruction has made drastic, detrimental changes in the Pacific and unfortunately continues to do so.

There are several interesting appendices. These start with a list of hypothetical birds, which includes species that have been introduced and thankfully died out. Only information on status and possible occurrence is given; no details are given to assist identification. There then follows a detailed island by island series of checklists and a set of regional maps. These latter identify the islands only, containing no information on the internal land masses. In addition to the colour plates, there are many black-and-white illustrations spread throughout the text. These are of the same excellent quality as the colour plates, but are intended to be useful rather than decorative. A glossary, bibliography, and index (plus, of course, the colour plates) complete the book.

The authors have made a useful contribution to the world's regional field guides, which I think will stand the test of time. Thus, I recommend you purchase the clothbound copy, despite it being more-than-double the price of the paperback. Hawaii is already a popular vacation spot, so many will find it useful. As the book covers the entire Pacific it is possible that it will inspire additional travel to the other islands. Perhaps it will also result in more effort for conservation.

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The Freshwater Fishes of Europe, Volume 1, Part I: Petromyzontiformes

Edited by Juraj Holcik. 1986. AULA-Verlag, Weisbaden, Germany. 313 pp., illus. DM 236.

Although there have been a number of successful popular guides to the freshwater fishes of Europe (such as B. J. Muus and P. Dahlstrom's 1971 *Collin's guide to the freshwater fishes of Britain and Europe*), a list of European freshwater fishes, and a number of good national ichthyofaunal works, there has not been a proper European ichthyofaunal study since H. G. Seeley's 1886 *The fresh-water fishes of Europe*. The first of this nine-volume series, some volumes to be in more than one bound part, is a welcome addition to ichthyological knowledge. The ninth volume will be devoted to species in danger of extinction.

This volume is dedicated to the memory of Vadim D. Vladikov. The book begins with a table of contents, a preface by Theodore Monod, an editor's foreword and list of symbols and abbreviations. The rest of the book is divided into three major parts: a general introduction to lampreys, the systematic part with species accounts, and an index plus a list of contributors to this volume. Contributors, who lend authority to this volume, are: Pier G. Bianco, Martin W. Hardisty, Juraj Holcik, and Claude B. Renaud.

The general introduction includes accounts of lamprey morphology, identification criteria, zoogeography, evolution, ecology, ontogeny, feeding, migration, and population structure. Such an introduction is not traditional in ichthyofaunal works. But it does permit the useful synthesis of information on several species, permitting generalizations which might otherwise have been lost. Species accounts typically emphasize the diagnostic differences. Holcik uses this section to discuss, for example, evolution of tooth patterns and the emergence of satellite species. A key to the genera is presented at the end of this section, and keys are presented later on to species of polytypic genera.

Ordinal, familial, and generic accounts precede the species accounts. The species accounts are very thorough. Headings of sections include: Synonyms, Holotype, Etymology, Description (Morphology, Karyotype, Protein specificity, Sexual dimorphism, Variations, Age and size variability), Subspecies, Hybrids, Distribution (and Introductions), Ecology (Habitat, Migrations, Hardiness, Feeding habits, Longevity, Growth, Population dynamics), Reproductive biology (Maturity, Gonads, Spawn, Spawning period, Spawning sites, Mating habits, Breeding

habits, Early ontogeny, and metamorphosis), Important diseases and parasites, Economic importance, and Literature. The account for *Petromyzon marinus* is 22 pages long (4.5 pages of references) and includes 4 figures.

This detailed species format yields an almost unprecedented degree of thoroughness for a faunal work. However, one is occasionally left with unanswered questions such as was the difference in mean numbers of myomeres in North American and European sea lampreys significant? Where data is not available the lack is pointed out — as for dentition and myomeres of *Caspiomyzon*, and the lack of reliable aging methods for lampreys. The range of this genus has been sharply curtailed following construction of dams in the Soviet Union.

Maps show geographic ranges by either shading, with spots or with both. Hopefully future volumes will indicate ranges only with spots, a more precise method. Descriptions are sometimes based (*L. kessleri*) on literature accounts. Hopefully material will be available for revised descriptions in future volumes.

Taxonomic changes supported in this work include the synonymization of *Lethenteron japonicum septentrionalis* with the nominate subspecies, proposal of *Lethenteron kessleri* as a distinct species and not as a subspecies of *L. japonicum*, and the synonymizing of *Eudontomyzon gracilis* with *E. danfordi*, and *E. vladykovi* with *E. mariae*. Holcik distinguishes *L. kessleri* from *L. japonicum* by its thread-like intestine (suggesting it is non-parasitic) and the large size but small number of eggs. Holcik argues for the recognition of three families of lampreys: Petromyzontidae, Mordaciidae and Geotriidae, citing the recent support given by study of chromosome complements. *Lethenteron* is treated as a genus distinct from *Lampetra*, contrary to the arguments of R. M. Bailey.

This series of volumes on freshwater fishes of Europe promises to be a landmark in European ichthyology. Dedicated ichthyologists will want to purchase their own copies, if their salaries permit, others will want their libraries to order it. The volumes are authoritatively written, attractively designed, and well bound. Editor, contributors, and publisher are to be congratulated.

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BOTANY

The Agaricales in Modern Taxonomy

By R. Singer. 1986. Fourth revised edition. Koeltz Scientific Books, Koenigstein, West Germany. 981 pp., illus.

This book is **the** standard technical guide to the genera of mushrooms in the world. It goes without saying, that all major taxonomic mycological libraries should acquire this publication. While the author's opinions also have a profound affect on how regional mycofloras and field guides are worded, the text itself requires a number of years of study to be usable. Over 5000 species of agarics are listed in 230 genera in 16 families. As in previous editions, there are complete descriptions of the genera, keys to the families and genera, and a lengthy synopsis of techniques, characteristic features, and history. To understand some of the impact of this book one has to be aware of its history and that of the author. Dr. Singer has been publishing continuously on mushroom taxonomy since the age of 16 in 1922. He has authored over 300 publications in English, French, German, Russian, Spanish, and Latin. He has collected and studied worldwide, notably in Europe, the U.S.S.R., and North and South America. This book has as its precursors two war time series published under unusual circumstances, *Das System der Agaricales* 1936–1943 (Ann. Mycol. (Berlin) 34: 286–378; 40: 1–132; 41: 1–189) and *Phylogenie und Taxonomie der Agaricales* 1939 (Schweiz. Zeit. f. Pilzk. 17: 23–28, 35–39, 52–57, 71–73, 84–87, 97–101). The first edition was actually published in a journal (Lilloa 22: 1–832. 1951), followed by editions in 1962 and 1975 by Cramer. His contributions to the understanding of agaric taxonomy are rivalled by those of only two other contemporaries, R. Kühner (France) and A. H. Smith (USA). Neither has had as great an impact on generic concepts, but rather they have excelled in other ways.

Field biologists, amateurs, and plant pathologists often complain about the proliferation of new names, resurrection of old names, and shifting concepts in mycology, particularly for the conspicuous fleshy fungi. These opinions should be tempered by the fact that our knowledge of the fungal flora and, in many respects their taxonomy, is 100 years behind that of vascular plants and by the fact that mushrooms are large fructifications of microorganisms. Through the years, Dr. Singer has published countless new specific and generic names, and new combinations. There are nearly 100 new

names in the Fourth edition, which includes four new species, and one new genus, *Janauaria* from South America. Unfortunately each of the new species has only a minimal description and no illustrations. Several vital features are omitted, e.g. spore sizes are given for only one, and the number of spores per basidium is not given.

One major digression from the previous edition was the removal of two genera with luminescent species, *Omphalotus* and *Lampteromyces*, from the Tricholomataceae (suborder Agaricineae) to the Paxillaceae (suborder Boletineae), based on biochemical studies in Dr. Bresinsky's laboratory. Whereas in the first two editions there were many massive shifts between genera or to new or newly recognized genera, based on new data, there has been a stabilization in the last two editions. This is the inherent value of Dr. Singer's opus, it is a cohesive and comprehensive monograph. Unfortunately such a tome has tended to suppress many good proposals by others which are contrary to Dr. Singer's views. Most genera proposed or resurrected by others in the intervals between editions are placed in synonymy, e.g. *Lentinula*, *Megacollybia*, *Rickenella*, *Gammundia*, *Conchomyces*, *Ossicaulis*, *Caulorhiza*, *Calathella*, *Cephaloscypha*, and *Phaeogalera*, although a few genera treated by others have been accepted, e.g. *Fissolimbus*, *Agaricochaete*, *Horakia* etc. Students of basidiomycete taxonomy would do well to keep an open mind on such matters and restudy the discussions on evolution, tissues types, ultrastructure, cultural features, or pigmentation by E. J. H. Corner, R. Kühner, D. Pegler, J. Ginns, E. Horak, and/or H. Cléménçon, before accepting R. Singer's classification in total.

Dr. Singer mentions that this is probably the last edition of *The Agaricales in Modern Taxonomy*, thus it seems appropriate and instructive to examine some of its basic premises. Recognition of a single order with suborders for the genera treated therein was justified by the statement (p. 147), "... This is in my opinion the logical step as long as we wish to maintain the Agaricales as a definite unit within the Basidiomycetes." This is somewhat illogical because the Agaricales can always be maintained as a definite unit but with different parameters. Increasingly, it has become evident from data in recent literature that the gilled mushrooms arose more than once, giving rise to more than one order. Dr. Singer admitted this at least in the case of the

lamellate genus *Lentinellus*, which was included in the Agaricales in editions 1 and 2, but excluded in 3 and 4, all while maintaining the Agaricales as a unit. A second premise is the assertion that Gasteromycetes (puffballs and allies) gave rise to some or all Agaricales. For over 50 years Dr. Singer has defended this idea and 17 pages are devoted to the discussion in this edition (pp. 131–145, 807–808). Accordingly none of the gasteroid agaric genera, e.g. *Gasterocybe*, *Thaxterogaster*, are included in the Agaricales. Many mycologists are not convinced by Dr. Singer's evidence and include various gasteroid genera in the Agaricales (see Savile's 1968 paper, Possible interrelationships between fungal groups, in *The Fungi*, Volume 3, pp. 649–675).

A number of taxonomic features pertinent to phylogenetic studies of agarics were overlooked or not accepted by Dr. Singer. First, the ability of a fungus to produce enzymes which selectively remove cellulose from wood (resulting in a brown rot) has proven to be a useful feature which is correlated with anatomical or morphological features in taxonomic studies of polypores. Similar studies amongst agarics support the recognition of (1) *Lentinula* for the Shiitake as promoted by Pegler, rather than *Lentinus* as maintained by

Singer, (2) *Neolentinus* and *Ossicaulis* as proposed by Redhead and Ginns contrary to Singer, but (3), also support recognition of *Hypsizygus* as proposed by Singer rather than synonymization with *Pleurotus* as maintained by Corner. Second, further research on sarcodimitic tissues, first recognized by Corner in 1966 but largely unaccepted by Singer, supports the recognition of the genera such as *Megacollybia*, *Caulorhiza*, *Gerronema* (in a very restricted sense), *Hydropus*, and *Xerula*, but does not support recognition of a large genus *Trogia* as originally proposed by Corner. Finally, studies on the lichenization of agarics have also led to the modification of generic limits different from Dr. Singer's.

The Agaricales in Modern Taxonomy remains the standard for mushroom taxonomy and is unlikely to be surpassed for depth and coverage of the Agaricales by any text in the coming century. We all owe a great deal to Dr. Singer.

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Physiological Ecology of Lichens

By Kenneth A. Kershaw. 1985. Cambridge University Press, New York. 293 pp., illus. US\$59.50.

Physiological Ecology of Lichens has been winning accolades in the academic world. This marks one of the first times a Canadian author has made significant impress on a discipline which, to judge from the dominance of lichens in our landscape, ought to be a Canadian specialty.

It must be admitted, however, that Kershaw's book is not likely to find a place in the library of the average field naturalist. Its text, written primarily for the professional researcher, will be only marginally accessible to amateurs not intimately conversant with the techniques and vocabulary of plant physiology.

This is not to say that *Physiological Ecology of Lichens* is without interest to naturalists, but rather that they will want to consult this book rather than to buy it. Throughout his book, Kershaw places special importance upon the desirability of understanding the workings of lichens *under field conditions*. The fact that it is the micro-environment of a lichen which is important to its ecology, and not its gross environment, could be easily construed as

Kershaw's central message. Time and again he urges his colleagues to pay closer attention to microclimate, arguing that until they do this, the results of their experiments will bear little or no relationship to what he calls "the operating environment" of lichens.

Having said which, perhaps it is appropriate that the most readable chapters of the book — at least to the layman — are the first and second, in which Kershaw presents a lucid introduction to the thermal and hygric environments under which lichens operate, and the last, Chapter 9, which discusses various possible physiological and morphological responses of lichens to different microclimatic conditions. The remaining chapters are devoted to technical overviews of first the ionic environment of lichens (3), and then their major physiological functions, namely nitrogen fixation (4), photosynthesis (5,6,7), and respiration (8). Following Chapter 9 is an extensive reference section listing about 400 titles (60 of which are the author's own!), and an index. The text is illustrated by two plates, seven tables and 174 figures. Unfortunately for the uninitiated, there is no glossary of terms.

The emphasis on field conditions will not come as a surprise to anyone who has followed the Ontario-based "Kershaw school" of lichen ecophysiology over the years. What may surprise, however, is the realization that a goodly number of the observations turned up by this approach represent no less a contribution to Canadian naturalist lore than to the advancement of biological science.

Did you know, for example, that:

- lichens vary seasonally in their ability both to respond to sunlight and moisture, and to tolerate heat stress. Capacity changes may be large and may be induced — even in air-dry thalli — in a matter of days.
- although lichens are unable to control water uptake and loss in the manner of most flowering plants (e.g. through the presence of roots, stomates, cutin, etc.), they do possess a wide range of potential morphological strategies. Thus, in order to reduce evaporative water loss, a lichen may become less finely branched, less wrinkled, paler in colour, or it may adopt a mat-forming habit.
- lichens can be remarkably responsive to atmospheric humidity, sometimes achieving 30% water content by weight under nighttime conditions which preclude dew formation, but which nevertheless allow them to carry on with nitrogen fixation and other metabolic processes.
- the extensive lichen mats which cover the forest floor over much of northern Canada do not hamper tree growth, as is usually thought, but actually enhance it by moderating soil moisture during the growing season.
- under bright sunshine on windless summer days, surface temperatures of dry crustose lichens may climb — even in the arctic — as high as 50° C. By contrast, thallus temperatures in hair lichens seldom rise more than a few degrees above ambient air values. Lichens, in other words, operate in very different environments, depending on growth form and microsite.

True to the reputation of its publishers, Cambridge University Press, *Physiological Ecology of Lichens* is an attractive book, securely bound and, with the exception of Figures 14 and 78, which are almost illegible, clearly printed. It is also essentially free of typographical errors; those noted were for the most part trivial, usually involving erratic commas.

On the negative side, it should be mentioned that the text displays a disconcerting disregard for current lichen taxonomic opinion. In a number of cases, outdated names have been adopted, for example *Physcia orbicularis* for *Phaeophyscia orbicularis*, and *Cladonia gonecha* for, presumably, *C. sulphurina*, while elsewhere Kershaw is blatantly inconsistent in his choice of epithets, e.g. in using both *Ramalina menziesii* and *R. reticulata*. More serious perhaps is the reference (p. 160) to "*Bryoria americana* subsp. *canadensis*" — an innovative, but nomenclaturally incorrect, combination for a taxon now usually accepted as *B. trichodes* subsp. *trichodes*.

Such inattention to taxonomic detail raises the somber possibility that at least some of the species names used by Kershaw in his discussions could be based on misidentifications. Among others this is certainly true of the report of "*Parmelia* (= *Pseudevernia*) *furfuracea*" from Colorado (p. 93); that species is not known to occur in North America. Similarly, one may ask whether the two physiologically very different "*Peltigera aphthosa* ecotypes" discussed on pages 248 and 249 might not in fact represent two separate species, possibly *P. aphthosa* and *P. leucophlebia*. Or again, is it certain that all of this book's many references to "*P. polydactyla*" actually refer to that species, and not, as seems possible, to one or more of its poorly understood, but ecologically very distinct, segregate species? One earnestly hopes that lichen physiologists have consistently had the good sense to set aside voucher specimens of their study material.

Previous reviewers of *Physiological Ecology of Lichens* — all of them from temperate latitudes — have to a greater or lesser extent bemoaned the predominantly boreal emphasis of this book which, as I have said, has been written by a Canadian worker. To Canadian naturalists, however, this is its strongest recommendation: that it tends to inform us specifically about the inner workings of lichens which are as much a part of our landscape as are trees and wildflowers. May this book soon find a secure place in the researches of all Canadians who like to write, lecture, or think seriously about lichens.

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Amanita of North America

By David T. Jenkins. 1986. Mad River Press, Eureka. 197 pp., illus. U.S.\$33.95.

The mushroom genus *Amanita* contains many of the most well-known, fatally poisonous, hallucinogenic, and choice edible fungi in the world. Dr. Jenkins' treatment is welcomed indeed as there has been no recent synopsis of the genus in North America. I have used this guide to identify specimens and found it quite workable. The keys are based totally on macroscopic features, thus making them usable in the field. It is evident not only from this publication, but also from lectures by, and discussions with Dr. Jenkins, that he is very familiar with the Amanitas of North America. Although all named species of *Amanita* known from Canada are included, there is virtually no Canadian content and this book would be more appropriately titled "*Amanita* of the U.S.A." If viewed this way there is little to criticize. There are brief introductory chapters on distinguishing characters, habitats, edibility, and study, keys to all 128 taxa included, and reasonably good colour photographs of approximately half the species. Synonymy is not given, nor are references cited in the text. Each species or variety recognized is numbered, followed by a highlighted brief, two to three line, synopsis of critical macroscopic features, and then a full description. This is an excellent format for those studying the genus, amateur and professional alike. While the book is intended to be a guide, not a technical monograph, it will be an influential book. Unfortunately, three invalidly published provisional names are recognized which should not be perpetuated in a semipopular publication.

It is the distribution listed in the paragraphs labelled, "Habitat and reported distribution," that will at first confuse and mystify Canadian readers. Only a single, rare, species, *A. solanoliens*, is reported from Canada, and this is out of necessity as the species is known only from Nova Scotia. *Amanita macrospora*, also recently described from

Nova Scotia, should have been similarly listed but the paragraph on distribution was omitted accidentally. *Amanita muscaria*, the commonest species in Canada, and probably present in all provinces and territories in one form or another, is not recognized from Canada. The citation of René Pomerleau's book *Flore des Champignons au Québec et Régions limitrophes* in the discussion on *A. caesarea* is viewed by the author as a reference dealing with a U.S. problem, not a North American problem, i.e. joint Canadian and U.S. problem. In addition, Canadian and other foreign users will at first have difficulty recognizing the standard postal abbreviations for the U.S. states cited in the distribution paragraph, e.g. for *A. vaginata*: AL, MA, MD, ME, MI, MS, NC, NJ, NY, OH, PA, SC, TN, TX, VA, VT, WV. With a change of title for this book, as suggested above, the above paragraph need not have been written.

There are at least 25 species of *Amanita* in Canada. For those wishing to annotate their copy with Canadian records consult the following references: Les Amanites du Québec, Le Naturaliste canadien 93: 861–887, 1966, by R. Pomerleau (24 species); Identity of two uncommon Amanitas in Quebec, Beih. Nova Hedw. 51: 191–197, 1975, R. Pomerleau; Nova Scotia Amanitas I., Proceedings of the Nova Scotian Institute of Science 31: 109–120, 1981, D. Grund and K. Harrison (5 species); Nova Scotian fungi. New species and records of amanitas for the province, Canadian Journal of Botany 52: 331–339, 1974 (8 species). Amanitas are also reported from various places in Canada in field guides by R. J. Bandoni and A. F. Szczawinski, J. W. Groves, R. Pomerleau, and H. T. Güssow and W. S. Odell, and in regional floras.

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Mushrooms in the Garden

By H. Steineck. 1981. (translated by V.L. and J.F. Waters, 1984). Mad River Press, Eureka. 152 pp., illus. U.S.\$10.95.

This is a well done English translation of *Pilze im Garten*, 1981, which is easy to read and clearly presented. The subject matter is very interesting and certainly to naturalists, biology teachers, and home gardeners will be a real eye opener. To fully appreciate the book, however, one must be a mycophile (lover of fungi), and already have some experience in the identification and recognition of mushrooms. Brief, but informative, chapters on the history of mushroom cultivation, fungal biology and life cycles, harvesting, and consumption of mushrooms are included. The bulk of the text is devoted to the description of conspicuous common species, and methods of cultivating or moving these to a garden. Techniques are described for growing various *Agaricus* species, from the grocery store variety to more exotic forest species, in cold beds, *Asparagus* patches, and under cover of trees. Other species are recommended for compost piles, open lawns, indoor cultivation, and as mycorrhizal symbionts with trees in orchards. Many, such as the Shiitake (*Lentinula edodes* = *Lentinus edodes*), Oyster Mushrooms (*Pleurotus ostreatus*), and Enoki, or Winter Mushroom (*Flammulina velutipes*) require wood or sawdust for growth. A variety of procedures are described based largely upon the author's experience. The statement, beauty is in the eye of the beholder, certainly applies here. Most ardent North American gardeners strive to

maintain a homogeneously green turf on their lawns. Fairy rings, ring-shaped bands of richer or poorer growth of the grass, produced by a number of species of grass land mushrooms are considered as unsightly. The causal agent, often *Marasmius oreades*, is usually regarded as a pest. However, *M. oreades* is edible, and can be cultivated in a lawn if desired. The author (p. 21) suggests that it can, "enliven lawns with its dark-green fairy rings." Similarly, rotting stumps, posts, and logs are usually discarded, and pressure-treated wood is used in gardens. The author points out the beauty of some wood decaying species and describes how to promote their growth under trees, along carefully placed logs, and on stumps upon which one may sit and contemplate nature.

A number of the species are endemic European species, particularly the truffles, but most also occur in North America. Therefore, the methods should apply here. *Phyllostopsis nidulans* (*Pleurotus nidulans*), a colourful wood decayer, was recommended by the author as a curiosity ornamental with an aromatic odor. However, most North American strains produce a nauseating odor somewhat like additives to natural gas.

I enjoyed reading this book and found it educational. It would be interesting to try the different techniques but perhaps not to the extent suggested by the author.

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A Utah Flora

Edited by S. L. Welsh, N. D. Atwood, S. Goodrich, and L. C. Higgins. 1987. Great Basin Naturalist Memoirs Number 9. Brigham Young University, Provo, Utah. 894 pp. U.S. \$40.00 + \$2.00 postage

It was not too many years ago that P. A. Rydberg's *Flora of the Prairies and Plains of Central North America* (1932) was the only flora that covered that part of the United States lying west of the Mississippi River and east of the Rocky Mountains. Since that time there has been a great surge of botanical activity in the region, and a number of floras have been written treating various parts. Three of the most recent floras are *Flora of the Great Plains* (1986), *The Vascular*

Plants of South Dakota (1976), and *Intermountain Flora* (Volume 1, 1972; Volume 4, 1984; and Volume 6, 1977). This latter work includes all of the state of Utah, but as yet only three of the projected six volumes have been published in a span of 13 years.

A Utah Flora has been written by a consortium of authors, four additional, E. C. Neese, L. A. Arnov, G. I. Baird, and K. H. Thorne, to the four editors. Welsh and Higgins however were the major contributors, Welsh being responsible for in entirety or in part for about 70% of the genera and 62% of the species, while Higgins provided the text for slightly more than 20% of the genera and 14% of the species. The treatment, according to the

editors, is a conservative one, and with this statement, I would agree. A total of 142 families, 765 genera, 3152 species (including 580 introductions), and 355 infraspecific taxa are keyed out and described in detail. Common names, synonymy, habitats, distribution in Utah and overall distribution are provided. Chromosome numbers are given when known but these have been taken from the literature and there is no indication if the counts were based on Utah material. Type specimens of most taxa described from Utah have been examined and their places of origin have been included with the species descriptions. References to pertinent monographs are frequently given following the generic descriptions. The arrangement of major groups is in the order of Fern Allies, Ferns, Pines and related families, Dicotyledons, and Monocotyledons. Within each of these groupings the families, genera and species are in alphabetical sequence.

In an abstract on page 1, attention is drawn to eight nomenclatural proposals found in the text: *Mertensia lanceolata* var. *nivalis*, *Chrysothamnus nauseosus* var. *uintahensis*, *Machaeranthera canescens* var. *latifolia* and var. *aristatus(a)*, *Viguiera longifolia* var. *annua*, *Dudleya pulverulenta* var. *arizonica*, *Cordylanthus kingii* var. *densiflorus* and *Cymopterus acaulis* var. *fendleri*. For the first of these, the basionym is provided, but not the place of publication and thus the transfer is

not valid [Article 33.2 of the International Code of Botanical Nomenclature (1983)].

An introduction written by Welsh outlines the historical basis of the flora, the philosophical basis and species concept, methodology, type of measurements used, gives comments on nomenclature, sources of common names, and the system of classification. Also included here is a short description of the environment which embodies comments on the physiography, plant communities, phytogeography, the modern setting with its impacts, acknowledgements, and a list of general references. A listing of author abbreviations, a glossary, and a combined index to common and scientific names completes the work.

Students of the flora of Utah and adjacent regions will welcome this most useful work. Some, whose eyes are not too good, will find the small type a handicap, but this was a necessity in order to get the vast amount of information on as few pages as possible. The paper is quite thin but the print on the reverse side of the page does not show through. One wonders, however, how long it will last with hard usage.

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Flora of the British Isles

By A. R. Clapham, T. G. Tutin, and D. M. Moore. 1987. Third edition. Cambridge University Press, New York. xxviii + 688 pp. U.S. \$125.00

The first edition of *Flora of the British Isles* by A. R. Clapham, T. G. Tutin, and E. F. Warburg was published in 1952. The need for such a flora has been amply demonstrated by the reprinting in 1957 and 1958, the second edition by the same authors in 1962, and now this third edition by Clapham, Tutin, and Moore.

In this third edition, the text has been completely reset. The new two column format on a larger page, with slightly narrower margins has reduced the number of pages significantly from the 1269 of edition two. The descriptions of genera and species, and the keys are essentially the same as in edition two, but have obviously been examined closely because occasional changes in wording and measurements demonstrate the inclusion of new

knowledge or a better way to describe some characters of a given plant.

There are a total of 79 plates of line drawings, three more than in edition one, but five less than in edition two. The quality of these illustrations has unfortunately suffered from edition to edition.

Users of this volume will find the information provided in addition to the quite detailed descriptions most helpful. An asterisk preceding the name of a species or genus indicates that it is certainly introduced. Chromosome numbers are given, and where this information has been obtained from British plants, this fact is indicated by an asterisk after the number. Common names, and in many cases several, are provided. Estimated numbers of genera and species in families and species in genera are given as well as the parts of the world where they occur. Habitats and distributions of individual species are provided, as in most floras, but there is also a wealth of information on

related species, subspecies, and genera that are frequently grown in British gardens, pollination data, and sources of information.

The most important feature of this third edition is, however, the fact that the taxonomy and nomenclature of *Flora Europaea* (1964–1980) have been largely adopted, thus, as stated by the

authors, “hastening the approach to a highly desirable uniformity”, a most welcome feature.

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Botanical Studies in the Lake Hazen Region, Northern Ellesmere Island, Northwest Territories, Canada

By James H. Soper and John M. Powell. 1985. Publications in Natural Sciences, No. 5. National Museums of Canada, National Museum of Natural Sciences, Ottawa. vi + 67 pp., illus. Free.

Until recently, the region of upper Ellesmere Island belonged to one of the least-known parts of Canada. Yet, considering its position above the 82nd parallel, it is a region of boundless scenic beauty, and of a surprisingly rich floristic diversity and wildlife. In one word, an oasis of serenity and unspoiled, undisturbed wilderness. No wonder most of the upper Ellesmere Island area was proposed as Canada's, and the world's, most northern national park a few years ago.

It is for this reason that Soper's and Powell's monograph on the botany of Lake Hazen Region is a timely and welcome contribution to the sparse knowledge about an area which is in the forefront of the present public interest.

The booklet offers more than its title heralds. Although a prevalent part of its 67 pages is preoccupied by botany, the first 18 pages are devoted to what can be summarized as natural history of the Lake Hazen region. This section includes information on Topography, Geology, Glaciation, Geomorphology, Soils, and Climate. Valuable is a chapter on the history of botanical (actually biological) explorations of northern Ellesmere Island. It covers in much detail the early pioneer and subsequent more systematic research activity of the European, American, and Canadian explorers.

The botanical information contained in the volume is a summary and a follow-up of investigations carried out by the authors between 1957–59. They were fortunate to participate in the “Expedition Hazen” which was part of the already historical, International Geophysical Year.

Although preliminary reports on the Lake Hazen work were published shortly after the project's termination, the present book represents a somewhat belated yet much appreciated summary of the authors' old research. It is introduced by an annotated list of an astonishing number (125) of vascular plant species, followed by a thorough description of 12 of the most typical habitats and the composition of their plant communities. Decently reproduced, excellent black-and-white photographs illustrate better than many words each of the habitats within the often bizarre Lake Hazen landscape. Included is information on seasonal progress of flowering and on phytogeographical affinities of the vascular plants. The monograph is equipped with a comprehensive bibliography on northern Ellesmere Island.

The publication may serve as an excellent, and so far the only, comprehensive guide to the natural history, basic ecology and flora of the Lake Hazen area, provided that the user recognizes the plants, or is equipped with a key to arctic plant identification. Due to the nature and objectives of the booklet, the interesting and rich world of Lake Hazen animals is not included. The prospective visitor will have to look to other more or less direct sources.

It is with regret that this excellent piece of work was published as a soft-cover cheaply-stapled brochure, suitable more for various archive shelves rather than for the general public where it could provide an excellent educational service.

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The Vegetation and Phytogeography of Sable Island, Nova Scotia

By P. M. Catling, B. Freedman, and Z. Lucas. 1985. Proceedings of the Nova Scotian Institute of Science 34(3/4) [1984]: 181–247. Nova Scotian Institute of Science, MacDonald Science Library, Dalhousie University, Halifax. viii + 66 pp., illus. \$10.00

Sable Island, graveyard of the Atlantic, home of feral horses, breeding grounds of Grey Harbour Seals and of an endemic bird subspecies, the Ipswich Sparrow, is a narrow sand ridge sitting out in the North Atlantic about 100 miles east of Halifax, Nova Scotia.

This mist-shrouded, windy land of shifting sand is the emergent top of a sandy deposit near the edge of the continental shelf. The visible part forms a crescent-shaped sandbar about 20 miles long and up to three quarters of a mile wide. Its surface is spotted with a number of fresh and brackish water ponds; there are open sandy areas, beach grass dominated dunes and low shrub communities with species such as Wild Rose (*Rosa virginiana* Mill.), Bayberry (*Myrica pensylvanica* Loisel.), and low junipers (*Juniperus communis* L., and *J. horizontalis* Moench.).

Sable Island has attracted botanists since early in the history of Canada. In 1899, Professor John Macoun was the first Canadian botanist to collect plants on the island. He was followed in 1911 by Dominion botanist, Dr. Hans T. Güssow. The classic work on the vegetation of Sable Island, however, was that of American botanist, Harold St. John. As well as cataloging the plants, including the unpublished lists of Macoun and Gussow, St. John provided an interesting account of the history of the island and its vegetation. In 1953, intrepid botanist, ardent collector and indefatigable naturalist, John Erskine, visited Sable Island and collected plants on behalf of the Nova Scotia Museum.

The oldest reference to Sable Island according to the authors "was contained in an ancient Icelandic saga describing the voyage of Biorn Heriulfson in 986 who, having passed Newfoundland and Nova Scotia (Helluland and Markland), came in sight of a barren sandy island." Early Nova Scotian naturalist Bernard Gilpin (1858), gives a picturesque view of Sable Island. As cited by the authors, Gilpin described the "grassy hill and sandy valley fading away into the distance . . . the tall coarse grasses cover the surface of the ground, alternating with sandy barrens and snowy peaks of blown sand . . . the wild rose, blue lily, and wild pea enamel the valleys. Strawberries, blueberries, and cranberries are in abundance . . . measured by

bucketful . . . as autumn heats the luxuriant green, the tall mallow, gay golden rods and wild China asters are swept by the heaving gales."

The present work maps the vegetation and describes eight plant communities ranging from dry-grassy to moist-heathy, and pond edge communities. Quantitative descriptive data are provided for 27 sites, including all the communities except the pond edge and aquatic communities, which are described in terms of their species composition and relative abundance. Two diagrams and two pages are devoted to the probable vascular plant succession on dry sites, wet sites, fresh water sites, and brackish water pools.

The research team of Catling, a botanist; Freedman, an ecologist; and Lucas, a writer and self-taught biologist who has spent much time on the island, is well qualified to provide an up-to-date picture of Sable Island and its vegetation. Each of the authors has visited the island on several occasions. During the summers of 1981, 1982 and 1983 they collected the data for this book.

The authors attempt to bring the nomenclature of earlier plant lists up to date, and to indicate the status, habitat, and distribution of various taxa. They present climatic data, and speculate about factors affecting the floristic composition, phytogeography, and the status of rare taxa and those restricted to Sable Island.

The book concludes with an annotated list of the island's recorded 239 vascular plant taxa, including species reported by earlier botanists, but not seen by the present team, and believed to be extinct. The lichens, bryophytes, and one charophyte (*Nitella* sp.), are not included in the list, but can be ferreted out of the plant community descriptions. The text is supported by 20 photographs of variable quality, but which none-the-less, help the reader to visualize the landscape.

The book provides a framework for future observations, and a foundation for assessing changes in the island's biota. Furthermore, it lays the groundwork for intelligent management of the area.

The Sable Island flora is an attenuated one, with many of the same species that characterize coastal barrens, sand dunes and similar exposed sites on mainland Nova Scotia.

Even the lichens, *Cladina stellaris* (= *Cladonia alpestris*), *Cladina rangiferina* (= *Cladonia rangiferina*), and *Coelocaulon aculeatum* (= *Cornicularia aculeata*), the hepatic *Cladopodiella fluitans*, and the mosses *Sphagnum*

palustre, *S. imbricatum*, *Aulacomnium palustre* (= *Mnium palustre*) are species common in suitable habitats on mainland Nova Scotia.

The authors report 154 native vascular plant species and 79 introduced species. For the most part, the introduced flora is confined to areas around old buildings, and the plant communities are dominated by native species. One notable exception is the introduced heather, *Calluna vulgaris*, which the authors report made up 92.4% of the relative cover of one of the shrub communities they sampled. There are no native trees, and despite intensive afforestation attempts, virtually no surviving introduced trees. (The authors report two trees of white spruce, *Picea glauca*, surviving out of 2500 trees planted in 1901, and one stunted tree of Scots pine, *Pinus sylvestris*, remaining from a more recent planting.)

Not surprisingly in such a harsh climate, many of the Sable Island species have northern affinities. Even the freshwater ponds have such northern ranging species as *Potentilla palustris*, *Nuphar variegatum*, and *Menyanthes trifoliata*.

Southern ranging species on Sable Island include several of the more wide-ranging members of the coastal plain element. Among these are species such as *Viola lanceolata*, *Drosera intermedia*, and *Calopogon tuberosus* (= *C. pulchellus*). Some of these, the authors list under "taxa with southern affinity;" others, such as *Calopogon tuberosus* var. *latifolius*, they list under "restricted plant taxa occurring on Sable Island."

Sable Island is a very special place. Its native flora may be the remnant of a once richer and wider ranging flora that in earlier geological time colonized the then exposed coastal plain. The island may have served as a refugium during the last glaciation.

It is this special character that no doubt leads the authors to over-emphasize endemism in the island's flora. Figure 26, for instance, is titled "*Bartonia paniculata* var. *sabulonensis*, a variety endemic to Sable Island . . ." Roland and Smith (1969, p. 582), however, report that this variety occurs "in swales, sandy shores, and cobbly margins in southern Yarmouth, Shelburne and Lunenburg counties" of mainland Nova Scotia, as well as on the islands of St. Pierre and Miquelon. Figure 27 is labeled: "*Calopogon tuberosus* var. *latifolius*, a variety of Grass Pink Orchid endemic to Sable Island and the Magdalen Islands . . ." Roland and Smith (1969, p. 225) note that as well as occurring on Sable Island and the Magdalen Islands, this variety occurs at Peggy's Cove, Halifax County, Nova Scotia.

Sable Island has, in fact, no endemic plant species, and it has only one species, the semicosmopolitan *Anagalis minima* (L.) E. H. L. Krause (*Centunculus minimus* L.), that in Eastern Canada is known only from the Island. Only three plant varieties are, strictly speaking, endemic to Sable Island. They are: *Epilobium nesophilum* Fern. var. *sabulonense* Fern., *Oenothera cruciata* Nutt. var. *sabulonensis* Fern., *Hieracium scabrum* Michx. var. *leucocaula* Fern. & St. John.

In contrast to this emphasis on endemics, no mention is made of the "wides," plants with extraordinarily broad disjunct distributions, although the flora of Sable Island has several good examples. *Potamogeton oblongus*, and *Juncus bulbosus* are treated as amphi-Atlantic, but *Polygonum raii* and *Centaureum erythraea* Rafn (*Centaureum umbellatum* auct.) are treated as suspected introductions. (See the discussion of *C. littorale* (D. Turner) Gilmour, in Webster 1978, p. 278).

Despite the authors' claim (p. 187) to have brought the nomenclature up-to-date, the species lists, for the most part, only correspond to names in Gleason and Cronquist (1963). In some cases, the names in the text body are different from those cited in the Annotated List. For example: *Convolvulus sepium* in the text becomes *Calystegia sepium* in the List; *Euphrasia bottnica* p. 218 (a species endemic to the Gulf of Bothnia in Sweden and Finland: see Yeo 1978, p. 305), in the List becomes *Euphrasia randii*, a species common on the mainland sea cliffs along the Atlantic coast and Bay of Fundy; *Atriplex patula* var. *hastata* in the text, becomes *Atriplex prostrata* Buch. (sic) in the List. The list is sprinkled with uncouth names. Sometimes the differing names apparently represent different taxonomic judgements as to whether a taxon is better recognized as species or as a subspecies of a closely related European taxon. This seems to be the case with *Elymus arenarius* L. var. *villosus* Mey. Fernald (1950) uses this name. Hultén (1968) calls the taxon *Elymus arenarius* subsp. *mollis* (Trin.) Hult. as do Porsild and Cody (1980). Rouleau (1978) calls the plant *E. arenarius* var. *villosus*. Since Bowden's (1957) cytotaxonomic study of the genus *Elymus*, most authors have recognized the taxon at the species level as *Elymus mollis* Trin. (Gleason and Cronquist 1963; Roland and Smith 1969; Dore and McNeill 1980). Because of the distinctiveness of this taxon the name *Lemus mollis* (Trin.) Pilger is now being used for this grass. *Agrostis scabra* Willd. var. *gemminata* (Trin.) Swallen is, however, the correct name for the taxon that Catling et al.

call *Agrostis hyemalis* (Walt.) B.S.P. True *A. hyemalis* is a more southerly species that does not get into Canada, (Dore and McNeill 1980; and M. J. Harvey, personal communication). Hultén (1968) and Rouleau treat both *Agrostis scabra*, and *A. hyemalis* as separate species and according to Rouleau both species occur in Labrador, Newfoundland, and the islands of St. Pierre and Miquelon.

Potentilla pacifica, in the List of Catling et al., should be *Potentilla egedii* s.l. Both Thannheiser (1984) and Hultén (1968) concur that *Potentilla egedii* Wormsk. subsp. *egedii* var. *groenlandica* (Tratt.) Polunin is the taxon that occurs in eastern Canada on the coasts of the Atlantic provinces. Further south along the coast, this species is replaced by *Potentilla anserina* L.

With the exception of a few genera such as *Honkenya*, and *Calystegia*, and the native orchids, there has been little attempt to bring names, especially of the introduced species, up to date with, for example, *Flora Europaea*. *Reynoutria japonica*, for instance, appears in the List as *Polygonum cuspidatum*; and *Juncus ambiguus* Guss. (Cope and Stace 1978, p. 123) appears in the List as *Juncus bufonius* var. *halophilus*.

Why the name *Lathyrus maritimus* (L.) Bigel. was chosen by Catling et al. in preference to the more familiar *Lathyrus japonicus* Willd., I have not been able to find out. This name and authority seems only to be in Gleason and Cronquist (1963, p. 418). Hultén (1968, p. 672) uses *Lathyrus maritimus* but gives Linnaeus as the authority, and describes two subspecies: subsp. *maritimus* and subsp. *pubescens* (Hartm.) C. Regel, both of which, according to Hultén's maps, occur in Nova Scotia.

According to the authors, the size of Sable Island has been diminishing since surveys in the 1700s, when it was 48 km long and 3 km wide. The island further diminishes, however, between p. 184 of Catling et al., where it is "42.5 km with a maximum width of 1.4 km," and p. 196, where the Island has become "32 km long and less than 1 km wide."

Roland (1982) describes the visible emergent part of the Island as "about 34 kilometres long and a little over a kilometre wide, but this is extended underwater by a bar at each end to make a length of 80 kilometres." Roland (1982) further notes that "Sand waves and ripples on the bank point to a wave migration around it and recent deposits of silt and sand in several directions off the bank and down the sides of the continental shelf indicate a transfer or 'spill off' away from the bank and its

emergent island. This down-slope movement is probably continuing and, if there is no drop in sea level, Sable Island is most likely ultimately to disappear."

As the authors point out, "the existing vegetation of Sable Island is remarkable and valuable, but it is likely that it was even more diverse and interesting prior to its first visitation by European man in the early 1500's."

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FRANCIS R. COOK
Editor

TABLE OF CONTENTS (concluded)

status of the Longear Sunfish, <i>Lepomis megalotis</i> , in Canada	G. N. MEREDITH and J. J. HOUSTON	277
status of the Green Sturgeon, <i>Acipenser medirostris</i> , in Canada	J. J. HOUSTON	286
status of the Paddlefish, <i>Polyodon spathula</i> , in Canada	B. J. PARKER	291
status of the Pacific Sardine, <i>Sardinops sagax</i> , in Canada	JACOB F. SCHWEIGERT	296
status of the Sea Mink, <i>Mustela macrodon</i> , in Canada	R. R. CAMPBELL	304
status of the California Sea Lion, <i>Zalophus californianus</i> , in Canada	MICHAEL A. BIGG	307
status of the Steller Sea Lion, <i>Eumetropias jubatus</i> , in Canada	MICHAEL A. BIGG	315
status of the Atlantic Walrus, <i>Odobenus rosmarus rosmarus</i> , in Canada	PIERRE R. RICHARD and R. R. CAMPBELL	337
status of the Fin Whale, <i>Balaenoptera physalus</i> , in Canada	GREGORY N. MEREDITH and R. R. CAMPBELL	351
Current status of the Gray Whale, <i>Eschrichtius robustus</i>	RANDALL R. REEVES and EDWARD MITCHELL	369
status of the Narwhal, <i>Monodon monoceros</i> , in Canada	JOHN THOMAS STRONG	391
Book Reviews		
Ornithology: The Bird Watcher's Diary — A field Guide to the Birds of Hawaii and the Tropical Pacific — The Freshwater Fishes of Europe, Volume 1, Part 1: Petromyzontiformes		399
Botany: The Agricales in Modern Taxonomy — Physiological Ecology of Lichens — Amanita of North America — Mushrooms in the Garden — A Utah Flora — Flora of the British Isles — Botanical Studies in the Lake Hazen Region, Northern Ellesmere Island, Northwest Territories, Canada — The Vegetation and Phytogeography of Sable Island, Nova Scotia		402
New Titles		412
Advice to Contributors		418
Following date of the previous issue: 102(1): 14 October 1988		

Articles

- The wing-moult of fulmars and shearwaters (Procellariidae) in Canadian Atlantic waters R. G. B. BROWN 20
- The parasitic dodders (*Cruscula*: Cuscutaceae) in Ontario WILLIAM J. CRINS and BRUCE A. FORD 20
- Effect of lichen and in vitro methodology on digestibility of winter deer diets in Maine JONATHAN A. JENKS and DAVID M. LESLIE, JR. 21
- Age structure analysis of a virgin White Pine, *Pinus strobus*, population TERESA A. HOLLA and PEGGY KNOWLES 22
- Ecology of the Mule Deer, *Odocoileus hemionus*, along the east front of the Rocky Mountains, Montana HELGA IHSLE PAC, WAYNE R. KASWORM, LYNN R. IRBY and RICHARD J. MACKIE 22
- Aspects of history and nestling mortality at a Great Blue Heron, *Ardea herodias*, colony, Quetico Provincial Park, Ontario JOSEPH P. SULLIVAN and SUSAN M. PAYNE 23
- Diet of the Kelp Snailfish, *Liparis tunicatus* in Jones Sound, Canadian High Arctic TIM BYERS and R. W. PRACH 24
- Water beetles of some saline lakes in Saskatchewan B. V. TIMMS and U. T. HAMMER 24

Notes

- Southern range extension of the Dusky Rockfish, *Sebastes ciliatus*, in British Columbia LAURA J. RICHARDS and S. JERGEN WESTREIM 25
- The Wandering Shrew, *Sorex vagrans*, in Alberta HUGH C. SMITH 25
- First breeding record of the Dunlin, *Calidris alpina*, on Baffin Island, Northwest Territories JEAN-LOUIS MARTIN, ALEX CLAMENS, and SYLVIE BLANGY 25
- Persistent attempts by a male Calliope Hummingbird, *Stellula calliope*, to copulate with newly-fledged conspecifics DOUG P. ARMSTRONG 25
- European Frog-bit, *Hydrocharis morsus-ranae*, in the Lake Ontario marshes HARRY G. LUMSDEN and DAVID J. McLACHLIN 26
- A disjunct population of the Blue-spotted Salamander, *Ambystoma laterale*, in southwestern Nova Scotia JOHN BROWNLIE 26
- Reoccupation of Common Loon, *Gavia immer*, territories following removal of the resident pair PETER ROSS CROSKERY 26

News and Comment

- Editors Report for Volume 101 (1987) — Proceedings of the Urban Natural Areas Workshop — Alfred Bog 26
- Status of the Green Sunfish, *Lepomis cyanellus*, in Canada G. N. MEREDITH and J. J. HOUSTON 27

concluded on inside back cover

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Cover: National Museum of Canada field truck and party at Mile 36 of Canol Road in 1944. From the left W. H. Brefenton, A. J. Breitung, A. L. Rand and J. A. Stoltz. Taken by A. E. Porsild. National Museum of Natural Sciences photographic files, negative number 98123 (located and provided by C. Kirby and J.-P. Brisson). See tributes and bibliographies for A. L. Rand (pp. 564-571) and A. J. Breitung (pp. 572-577).

The Canadian Field-Naturalist

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Cougar, *Felis concolor*, Sightings in Ontario

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Three hundred and eighteen sightings of Cougars, *Felis concolor*, were reported in Ontario for the period 1935 to 1983, and were evaluated by Ontario Ministry of Natural Resources staff. Most sightings were made in wilderness areas. About half of the sightings were reported from areas outside the deer range. None of the sightings was confirmed by positively identified Cougar tracks or other sign. Six areas in Ontario, relatively free from human disturbance and with good tracking conditions and repeated Cougar sightings, have been recommended as areas in which systematic searches for Cougar sign should be initiated.

Key Words: Cougar, *Felis concolor*, Ontario, sightings.

More than 300 sightings in Ontario from 1935 to 1983 and evidence from bordering Minnesota (W. Berg, Minnesota Department of Natural Resources, personal communication) and Manitoba (Nero and Wrigley 1977) suggest that Ontario might support a resident Cougar, *Felis concolor*, population.

The Cougar once ranged coast to coast from the Canadian Yukon to the southern tip of South America (Young and Goldman 1946; Hall 1981). In North America, European settlers persecuted the Cougar until it disappeared from most of its eastern North American range. The eastern subspecies, *Felis concolor couguar*, was considered extinct by the late 1800s (Young and Goldman 1946). Since then, however, increasing numbers of people have reported seeing Cougars throughout the eastern United States and eastern Canada (e.g. Cram 1925; Wright 1948; Bue and Stenlund 1953; Dear 1955; Wright 1961; Goertz and Abegg 1966; Clarke 1969; Thomson 1974; Lawrence 1983).

The earliest Cougar sighting in Ontario on record in the Ontario Ministry of Natural Resources (OMNR) files dates from 1935. However, earlier records of the Cougar's presence in Ontario are reported in the historical literature (Brodie 1894; Calcutt 1894; Orr 1911). Since the 1950s the number of sightings reported in each decade has increased substantially as follows: 1950 to 1959 — 28; 1960 to 1969 — 44; 1970 to 1979 — 138; 1980 to 1983 — 103 [H. Gerson. 1985. The

status of the Cougar (*Felis concolor* Linnaeus) in Ontario, with an overview of the status in Canada. Ontario Ministry of Natural Resources, Toronto. Manuscript].

There is evidence that Minnesota supports a small resident or transient Cougar population. Photographs of tracks in north-central Minnesota have been tentatively identified as those of a Cougar by M. Hornocker, a western Cougar authority. A Minnesota Department of Natural Resources wildlife biologist and other natural resource professionals have observed Cougars in the state (W. Berg, personal communication). Recent sightings of Cougars with kittens and of mating Cougars suggest a breeding population. Almost all the sightings in Minnesota are in the northern half of the state near the Ontario border (W. Berg, personal communication).

More than 260 sightings in Manitoba from 1930 to 1975 and a specimen collected in 1973 suggest that the species might be resident in the province. The animal was killed only 82 km from the Ontario border (Nero and Wrigley 1977; Wrigley and Nero 1982).

In this paper I describe the Cougar's distribution, habitat and behaviour in Ontario based on the records of sightings on file at the Wildlife Branch, Ontario Ministry of Natural Resources. These sighting records are not meant to serve as a basis for evaluating Cougar status or describing actual distribution. Publication of the Ontario sightings is meant to stimulate interest in alternate

methods of determining the status of the Cougar in Ontario. Locations where Cougar sightings have been reported repeatedly over the last four decades are recommended as areas that should be searched systematically for Cougar sign. Since the probability of obtaining a photograph or specimen of a Cougar is low, the discovery of cougar tracks identified by an authority is necessary to verify the presence of Cougars in Ontario.

Methods

Reports of Cougar sightings were investigated and recorded by staff of the Ontario Ministry of Natural Resources. Data collected for each record include, where possible, date, time, location, number of animals seen, observer(s), distance from animal(s), observation conditions, colour, estimated body length and shoulder height, presence of tail, estimated tail length, description of other features, behaviour, presence of tracks and habitat. I converted all estimated body measurements to metric units.

Sightings were divided into two categories — probable sightings and possible evidence. Sightings in the first group consisted of complete and accurate descriptions of Cougars or their sign. Sightings in the latter group consisted of reports of tracks, scats and vocalizations, incomplete descriptions of cougars, and second-hand information. Sightings in the latter group were sometimes used as supporting evidence for some "probable" records.

Results and Discussion

Cougar Sightings

From 1935 to 1983, OMNR staff collected records of 318 sightings (189 probable, 129 possible). Sighting locations are shown in Figure 1. Through conversations with field staff, trappers and hunters, I learned that many Cougar sightings, especially those from earlier years, have not been documented.

A high proportion of cougar sightings are not valid (R. H. Brocke 1981. Reintroduction of the cougar *Felis concolor* in Adirondack Park: a problem analysis and recommendations. New York State Department of Environmental Conservation. Manuscript). Van Dyke and Brocke (1987a) have concluded that compilation of sighting reports seems to be an unreliable method of assessing Cougar presence. Nevertheless, compilation of sighting reports is a necessary step in the investigation of the Cougar in Ontario.

Description of Cougars

Descriptions generally consisted of a tan or brown animal with a long tail and cat-like features,

and sometimes included details such as a white chin, chest and throat, black markings on the face, ear tips and tail tip, and a lighter colour ventrally. Some observers described the tail as rope-like, drooping down and turned up at the tip. Observers often reported that the hind legs were larger than the forelegs. Of 137 observations of the animal's colour, 35% were brown (often light brown or reddish brown), 15% were tan, 14% were tawny, 9% were black, 8% were fawn, 5% were beige and 4% were yellow. The remaining 10% were grey, gold, sandy or rusty.

Estimated mean body measurements are as follows: body length from snout to base of tail — $136 \text{ cm} \pm 44 \text{ cm}$ (S.D.) ($N = 46$); shoulder height — $67 \text{ cm} \pm 19 \text{ cm}$ (S.D.) ($N = 67$); tail length — $75 \text{ cm} \pm 19 \text{ cm}$ (S.D.) ($N = 28$). Observer estimates were consistent with body measurements reported in the literature (Banfield 1974; Hall 1981).

Behaviour and Vocalization

The activities of Cougars noted in 121 sightings were as follows: 30% walking, 26% running, 17% leaping, 10% standing, 5.5% lying down, 5.5% sitting, 4% eating or chasing prey, 1% drinking and 1% swimming. Movement of the tail from side to side was described in eight reports. The Cougar's apparent indifference to being observed or approached as pointed out by Nero and Wrigley (1977) is mentioned in 13 of our reports. Two observers claim to have approached a Cougar to within a distance of about 8 m before it walked away.

Vocalizations of Cougars described as snarls, screams, screeches, yowls, roars, shrieks, hisses and growls were reported on 18 occasions. Cougars that were approached closely by observers sometimes snarled or hissed. The other vocalizations usually were heard at night or when Cougars were not in sight, and therefore could not be attributed definitely to Cougars. Cougars are generally silent (Seidensticker et al. 1973), although they can call loudly and probably do so during mating time (Wright 1959).

Season and Time of Sightings

Cougars were seen in every month. Of 289 sightings in which the season was recorded, 48% were made in summer (June to August), 28% in autumn (September to November), 11% in winter (December to January), and 13% in spring (March to May). These results, which are similar to those reported by Nero and Wrigley (1977), probably reflect the amount of time people spend outdoors in the different seasons. Most sightings were made during daylight hours. Peak periods were between 0700 and

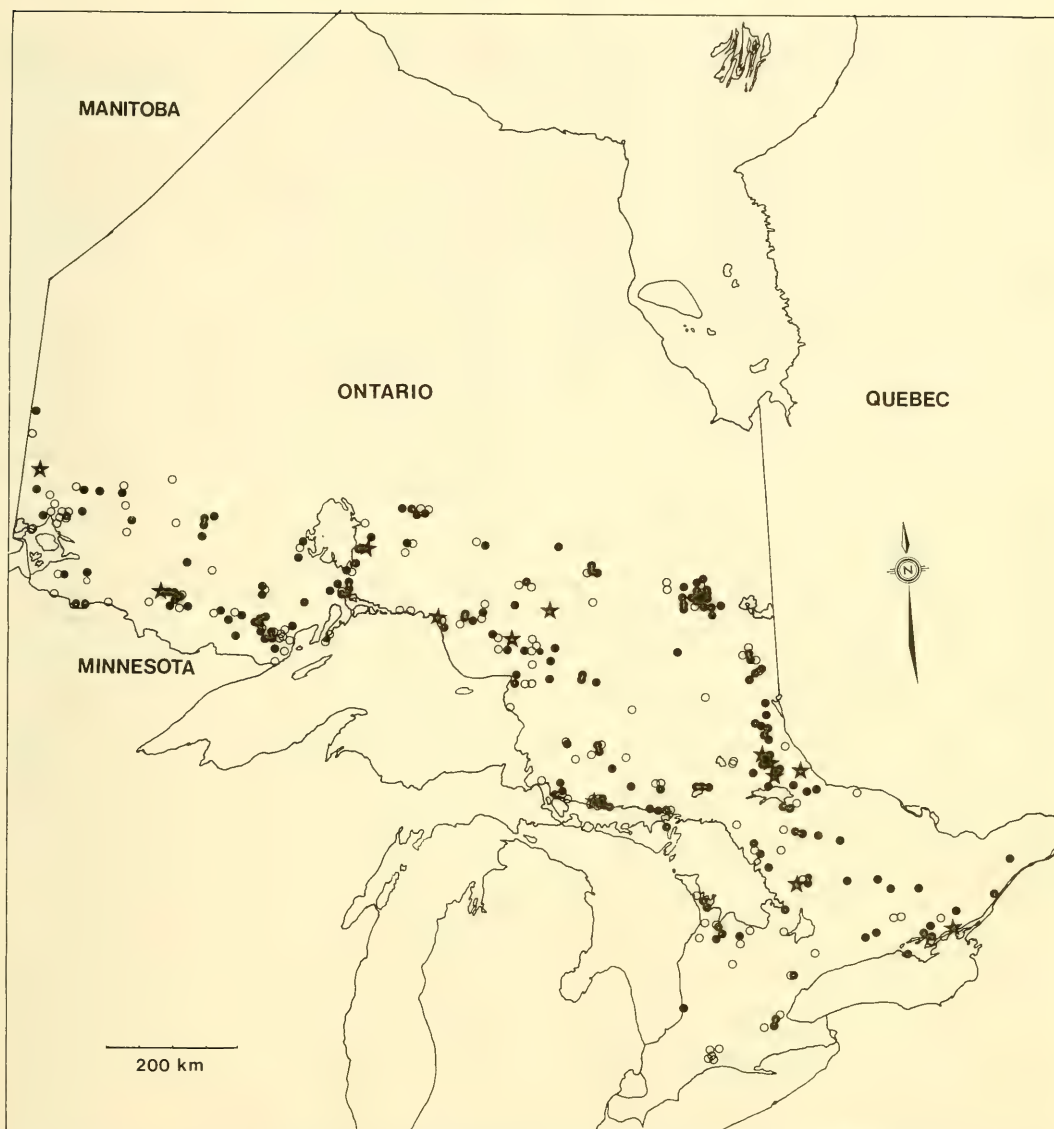


FIGURE 1. Locations of 318 Cougar, *Felis concolor*, sightings in Ontario, 1935–1983. Symbols: ● sightings with accurate descriptions; ○ possible evidence; ★ sightings of Cougars with kittens or of two or more Cougars.

1300 hrs (44%, $N = 95$), between 1500 and 1700 hrs (17%), and between 2000 and 2100 hrs (9%).

Sightings of Pairs and Young

There were twelve sightings of two or more Cougars seen together (Figure 1), including seven of an adult with one or more kittens. The Cougar is generally a solitary animal. Adult males and females become established on “home areas” or territories

before they breed, although “transient” males may occasionally breed (Seidensticker et al. 1973). For this reason, sightings of two or more Cougars (adults and young or breeding adults) may provide evidence of a resident Cougar population.

Prey and Distribution

In Ontario, there are 18 reports of Cougars said to be chasing or eating prey, or implicated in the

injury, death or removal of domestic livestock. The prey species in these records consist of deer (2), Red Fox (*Vulpes vulpes*) (1), Snowshoe Hare (*Lepus americanus*) (1), Woodchuck (*Marmota monax*) (1), Beaver (*Castor canadensis*) (2), Porcupine (*Erethizon dorsatum*) (1), pig (2), horse (1), sheep (2), cattle (4) and bait (1).

In Manitoba and New Brunswick, the distribution of Cougars (based on sighting records) is similar to that of deer, the major prey species (Wright 1972; Nero and Wrigley 1977; van Zyll de Jong and van Ingen 1978). In Ontario, the northern limit of the White-tailed Deer (*Odocoileus virginianus*) range is much farther south at present than that indicated in Peterson (1966) and Banfield (1974) [Smith and Verkrusye 1983].

About half of the Ontario Cougar sightings were reported from areas outside the present White-tailed Deer range (Smith and Verkrusye 1983), although other prey, including Moose (*Alces alces*), Woodland Caribou (*Rangifer tarandus*), Porcupine and Beaver are available in those areas. Spalding and Lesowski (1971) found that Cougars do prey on Moose in areas where Moose are common. Smaller prey species, such as Porcupine, Snowshoe Hare and Beaver may be locally important (Young and Goldman 1946; Robinette et al. 1959; Toweill 1977).

Although historical records indicate that the Cougar occupied only southern Ontario (Brodie 1894; Calcutt 1894; Orr 1908, 1909a,b, 1911), some accounts of its former distribution describe a much wider range, as far north as Hudson Bay (Fountain 1902; Ingersoll 1906). Lett (1887) believed that the Cougar "abounded, at one time, in the Valley of the Ottawa, in considerable numbers" and that "the panther was found in every part of Ontario and Quebec." Seton (1925) described a Hudson's Bay Company record of a Cougar that had killed a Caribou and was shot by an Indian hunter in northern Ontario, 15 miles north of Lake Témiscamingue [Timiskaming].

If the historical accounts of the wide range of the Cougar are accurate, the present distribution of sighting records in Ontario coincides with a liberal interpretation of the historical range. However, Cougar sightings are rarely reported in the heavily populated and cleared areas of southern Ontario.

Habitat

I have used Nero and Wrigley's (1977) habitat descriptions to group the Ontario Cougar sightings by habitat. The results are as follows: 64% "wilderness" (areas with few hard-surfaced roads or towns); 23% "mixed land" (agricultural land

and towns interspersed with large forest tracts); and 13% "farmland" (agricultural land with forest cover restricted to woodlots and river valleys). These results differ from those of Nero and Wrigley (1977), who reported 40%, 30%, and 30% in the respective categories above. According to Van Dyke et al. (1986a), dispersing Cougars in Utah and Arizona tend to select areas for residence that are characterized by absence of recent logging, relatively low road densities, and few or no sites of human disturbance.

Systematic Search Techniques for Cougar Sign

There are two convenient ways to investigate the presence or absence of Cougars in an area. The first is to search the area in the immediate vicinity of a sighting for tracks as soon as possible after the sighting and to conduct such a search for as many sightings as possible. The second method is to search along dirt roads in areas where sightings are common.

The first technique, briefly outlined here, is described in detail by Van Dyke and Brocke (1987b). For each sighting, the investigators searched the perimeters of five concentric squares of increasing size, centered on the sighting location. They determined the dimensions of each square by pacing (lengths of sides of squares are 43, 86, 129, 172 and 215 m). The results of their study of this search technique suggest that the probability of finding at least one track or other physical evidence of Cougar on bare soil or snow is 80% for up to nine days after a valid sighting, if the site has not been disturbed by precipitation or high winds.

Van Dyke and Brocke (1987b) proposed that sighting reports that meet the following criteria be investigated preferentially: (1) the observer can identify the exact location of the sighting; (2) the substrate at the sighting location is snow or bare soil; (3) the site can be searched within nine days of the sighting; (4) the site is not disturbed by high winds, precipitation or other disturbance after the sighting. When a site meets all of the above criteria, but does not yield conclusive evidence of Cougar presence, the validity of the sighting report is extremely suspect (Van Dyke and Brocke 1987b).

In the east, sightings are reported frequently in areas that seldom experience the conditions identified in points 2 and 4 above. The results from the Utah study suggest that even disturbed sites would reveal tracks or other physical evidence of a Cougar 33% of the time, assuming all sightings were valid (Van Dyke and Brocke 1987b).

Systematic searches of dirt roads in areas where Cougar populations were present indicated that

less than 90 km of dirt roads need to be searched in an area of 500 km² under ideal tracking conditions to find the track of any Cougar remaining in the area during the search period. The maximum search effort that should be necessary under less than ideal tracking conditions is 360 km of road searched per 500 km² of area (Van Dyke et al. 1986b). Searches may be conducted on roads with snow or dirt substrates, although snow lowers track persistence because of freezing, thawing, drifting and successive snowfalls (Van Dyke et al. 1986b). Also, Cougars tend to restrict movement after heavy snowfalls (Seidensticker et al. 1973), and therefore may cross roads less frequently (Van Dyke et al. 1986b).

Experienced Cougar hunters use other highly effective, but more subjective, methods to determine Cougar presence, usually involving intensive off-road searches in areas with specific terrain features. The services of such individuals should be engaged whenever possible to assess Cougar presence in an area (F. Van Dyke, personal communication).

Recommended Areas to Search for Cougar Sign

Resident Cougars studied in Arizona and Utah were rarely found in or near sites logged within the past six years and they selected home areas with relatively low road densities and little human disturbance (Van Dyke 1983; Van Dyke et al. 1986a). Transient Cougars were found in logged areas more often, but did not usually remain there (Van Dyke et al. 1986a). Cougars crossed improved dirt roads and hard-surfaced roads less often than unimproved dirt roads and were less likely to have hard-surfaced roads and improved dirt roads in their home areas than unimproved dirt roads, suggesting avoidance (Van Dyke et al. 1986b).

Based on this information, I have recommended six areas in Ontario that should be searched preferentially for Cougar sign. Within these areas, which are shown in Figure 2, there are sites that meet all of the following criteria: 1) not closer than one km to sites being logged at present or logged within the past six years; 2) few or no sites of human residence; 3) no major permanent human disturbance, habitat alteration or human presence; 4) low road densities (i.e. 50 km of road/100 km²), but enough passable dirt roads to conduct a search of at least 90 km of roads per 500 km²; 5) mainly sand or clay unimproved dirt roads and few improved dirt roads and hard-surfaced roads (many other areas meet all criteria except this one, since logging roads in Ontario are often covered with gravel); 6) repeated Cougar sightings over

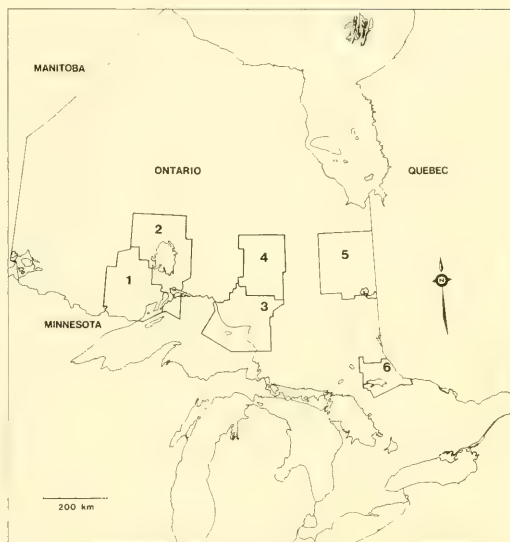


FIGURE 2. Six areas in Ontario in which systematic searches for Cougar sign are recommended. The OMNR administrative districts and areas within the districts are 1 = Thunder Bay District — west of Thunder Bay; 2 = Nipigon District — south and east of Lake Nipigon and Limestone Lake area; 3 = Wawa District — northwest of White River, north of Highway 17; south and east of White Lake; between Highway 17 and Pokej Lake, south of White River; and Obatanga Provincial Park; 4 = Hearst District — Oba south to Irving Township; 5 = Cochrane District — south, north and west of Cochrane; 6 = North Bay District — Marten River area.

many years or sightings of two or more Cougars or Cougars with young.

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Behavior Responses and Reproduction of Mule Deer, *Odocoileus hemionus*, Does Following Experimental Harassment with an All-terrain Vehicle

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Five Mule Deer (*Odocoileus hemionus*) does were caught by helicopter and net gun and were equipped with radio collars. They were habituated to an all-terrain vehicle (ATV) travelling the same truck trail for 12 weeks. Three of the females were then followed by ATV for 9 minutes per day for 15 days between 1 to 24 October, 198, for a total of 135 minutes. The harassed females, but not the other females, shifted feeding into darkness, used cover more frequently, left their home ranges more often, and increased flight distance from the ATV. In the following year the three harassed females collectively raised 1 fawn, having had normal reproduction the year before and the year after. Neither the unmarked females in the study area nor the two radio-collared control females suffered decreases in reproduction during the study. These results confirm expectations and are statistically significant.

Key Words: Mule Deer, *Odocoileus hemionus*, disturbance, harassment, reproduction, Alberta.

Harassment of wildlife has been considered detrimental ever since the late middle ages in Europe, when edicts were issued by local rulers banning entry to forests during calving seasons of Red Deer (*Cervus elaphus*). Despite the lowly regard of nobility for commoners, such prohibitions were still not issued lightly. Economic hardship was imposed on peasants by such bans because they used forests heavily, not only for firewood and seasonal plant foods, but also for forage for their livestock (Stahl 1979: 144-145). The notion that wildlife requires freedom from disturbance is deeply engrained in central European thinking on wildlife management and in Germany it is anchored in law (von Raesfeld and Vorreyer 1978: 154).

Considerable evidence about the detrimental effects of harassment has mainly been accumulated through close observation of husbanded stocks of domestic or semi-domestic herbivores (Klein 1971; Geist 1971, 1978), but also through the study of capture myopathy (Young and Bronkhorst 1971; Wobeser et al. 1976; Lewis et al. 1977; Chalmers and Barrett 1977) or physiological blood values (Franzmann and Thorne 1970; Hyvarinen et al. 1976), through the examination of displacement and reduction in habitat use (Rost and Bailey 1979; Basil and Lonner 1979; Morgantini and Hudson 1979), and displacement in time (Douglas 1971).

Of particular interest are the classical laboratory experiments by the late Howard Liddell and associates of various stressors applied to domestic caprids as reviewed by Moore (1968). The first experimental investigations of systematic harassment of a free-living big game animal were carried out by Batcheler (1968) in New Zealand on Red Deer. He found detrimental impact on body growth, reproduction and habitat selection. MacArthur et al. (1979, 1982) and Geist et al. (1985) concentrated on immediate physiological responses as indicated by heart-rate telemetry in Bighorn Sheep (*Ovis canadensis*).

However, capture by helicopter and net guns, trapping, handling and drugging of free-living Caribou (*Rangifer tarandus*) do not appear to have detrimental effects on individuals, neonatal production or post-natal survival (Hamlin et al. 1982; Valkenburg et al. 1983; Bergerud et al. 1984). Experience in an ongoing study of Caribou confirms these findings (Mahoney, Government of Newfoundland and Labrador, Wildlife Division, personal communication).

These studies of traumatic experiences differ from earlier ones which dealt with chronic disturbance. Also, Caribou, the species studied by Valkenberg et al. (1983) and Bergerud et al. (1984), is a cursorial form, and is expected to have more stamina than saltatorial runners (Gambaryan

1974). Another complexity is that stimuli need not be noxious by their very nature; rather, they become harassing stimuli only within the experience of the animal (Geist 1971, 1978). On the basis of learning theory (Hebb 1966), we expect animals to habituate readily to novel stimuli, except where such stimuli are either very rare, very violent, or where the stimulus pursues or hurts the animal. A stimulus gains "meaning" if the animal is repeatedly confronted by it. We address these points in the following experiment with Mule Deer, (*Odocoileus hemionus*).

Experimental Design and Methods

We subjected Mule Deer first to capture and handling by helicopter and net gun, then habituated them to potentially harassing stimuli (passes by an all-terrain vehicle), and then we selected individuals to be harassed by these stimuli. We expected no effects from trapping, nor any effects from the stimuli to which deer habituated, but we did expect behavioral and reproductive changes in the deer we subjected to experimental harassment.

We chose an unhunted population of Mule Deer on the Suffield Military Reserve in southeastern Alberta. These deer rarely saw vehicles or humans, since the study area was off-limits to military personnel, except military police. The area is formed of stabilized sand dunes, with a vegetation representative of the mixed prairie association of the northern Great Plains (Coupland 1950).

Five adult does were caught in June 1981 with helicopter and net gun and equipped with individually coloured radio collars. For 12 weeks thereafter, deer in the study area were subjected to the experimenter (CY) driving an all-terrain vehicle (Honda three-wheeled motorcycle) along a designated truck trail.

After the deer had become habituated to the ATV, we selected three radio-collared does for harassment. This procedure consisted of the experimenter following each designated doe for 9 minutes with his ATV, causing the deer to run and hide repeatedly. This dosage was considered safe because Mule Deer, as saltatorial runners, cannot be expected to run as long as cursorial reindeer, where running for up to 20 minutes is possible (Gambaryan 1974).

Harassment began on 1 October 1981 and terminated on 24 October. Each doe was pursued 15 times for a total of 135 minutes. Pursuit alternated between the first 2 hours and the last 2 hours of daylight. From 1 to 19 October the does were pursued every second day; from 20 to 24

October they were pursued daily. Although no more pursuits were made after 24 October, the deer were still subjected to the noises made by the experimenter's ATV in his travels through the study area from 25 October to 28 November.

The month of October was chosen for experimental harassment because that was the month during which does are expected to fatten just prior to mating (beginning about 15 November). We expected to impose stress to disrupt normal patterns of feeding and resting, and thereby affect body condition and possibly reproduction.

We recorded the frequency with which collared deer were found in open terrain (away from cover), the flight responses to the appearance of the ATV at a distance of 250 m or less, and the exact map location of each deer. We recorded, for all females in the study area, the presence or absence and number of fawns. We monitored collared deer for eight 24-hour periods following harassment (25 October to 2 November). The position of each deer was located every 2 hours by telemetry, and a record was kept on whether it was stationary or moving. We investigated the reproduction success of collared deer in August of 1981, 1982, and 1983 by locating each doe and checking repeatedly on whether fawns were present or not.

We constructed home ranges for each known deer based on observations from June to October 1981 by joining the outermost geographic sightings of each deer to form a polygon, following Hornocker (1969). We also tested the responses of hunted deer outside the military reserve to the ATV.

We chose to experiment with few individuals but to study them in detail. That is, we chose reliability of individual responses over representativeness. We lumped the results from the three experimental adult does, even though this violates the assumption of independence among samples. We did not consider this violation serious because samples were well spaced in time. We regarded a longitudinal study of individuals which were tested for expected responses to harassment superior to a short statistical study of many individuals of whose individual fate we would remain ignorant. Also, our experience and the published experiences of others have led us to expect marked responses by harassed deer.

The activity data were subjected to chi-square analysis (Zar 1974: 59). For analysis of data on use of open spaces versus cover, and on flight responses, we used Z-statistics for differences between proportions (Zar 1974: 296). To deter-

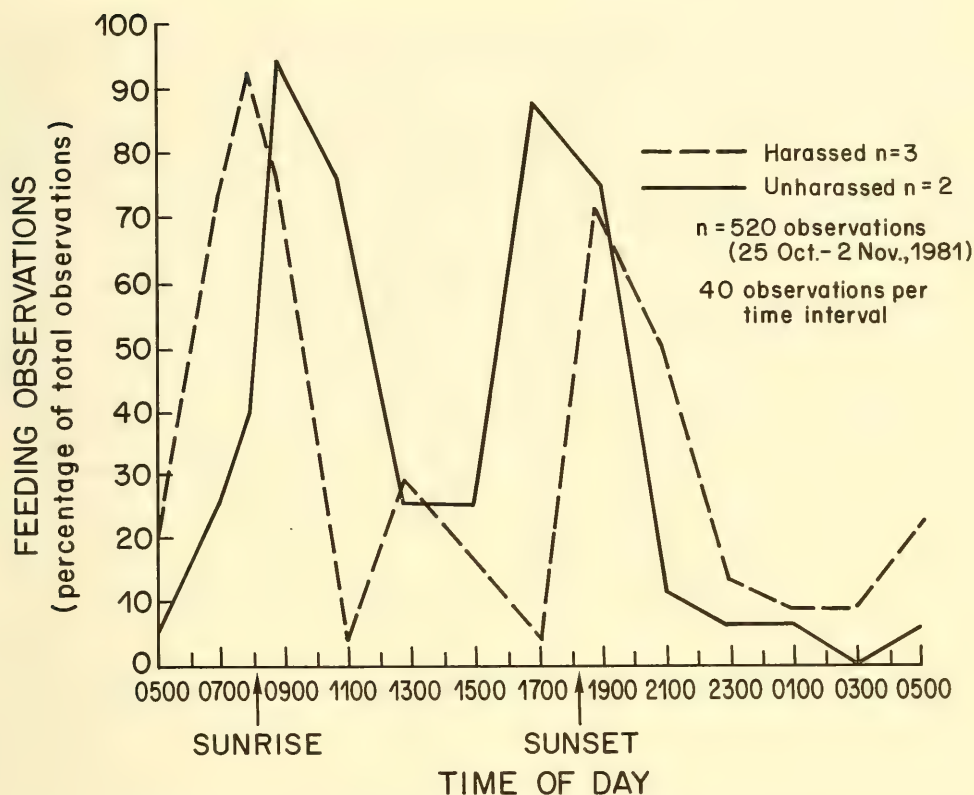


FIGURE 1. Daily feeding patterns of harassed and unharassed does for the period 25 October to 2 November 1981 in Suffield Military Reserve, Alberta.

mine the statistical significance of observed differences in the reproduction of the experimental deer, we employed an empirical probability distribution developed using data on how many unmarked does were observed with zero, one, two or three young.

Results

Daily feeding patterns (Figure 1) of three harassed and two unharassed does between 25 October and 2 November 1981 are based on 520 observations. The harassed does spent more time active during darkness than did unharassed does ($\chi^2 = 104.3$, 6 df, $P < 0.001$). The harassed does spent mornings and evenings, the times of day when the deer were normally harassed, in hiding.

The use of cover by harassed deer increased noticeably. From 1 to 30 September 1981, 220 observations were made of all collared deer; from 25 October to 28 November, 168 observations were

made of harassed deer, and 112 observations were made of unharassed deer. The corresponding percentages of these deer found in cover were 12, 33, and 10, respectively, and harassed deer made more use of cover than unharassed deer ($Z = 4.54$, $P < 0.001$). Use of cover by all collared deer before harassment trials, and by unharassed deer following trials, did not differ ($Z = 0.72$, $P > 0.05$). Pre-trial harassed deer made less use of cover than post-trial harassed deer ($Z = 4.19$, $P < 0.001$).

From 15 to 30 June, collared deer fled in 16 of 39 cases when the ATV approached within 250 m. Between 5 and 25 September collared deer fled in only 5 of 47 cases ($Z = 3.81$, $P < 0.001$). After the harassment trials, the collared deer fled in 62 of 77 instances; the unharassed deer fled on 5 of 33 occasions ($Z = 8.25$, $P < 0.001$). Flight responses of unharassed collared does from 25 October to 27 November and of all collared does prior to harassment did not differ ($Z = 0.21$, $P > 0.05$). The

difference in flight responses between collared deer prior to harassment (5–25 September) and harassed collared deer was considerable ($Z = 10.67$, $P < 0.001$).

In testing the flight response of hunted Mule Deer outside the Suffield Military Reserve (1 to 3 December) with the same ATV, 52 of 61 deer fled before the distance was closed to 250 m. This proportion is much the same as that of the harassed, collared does within the reserve, which was 62/77 ($Z = 0.51$, $P > 0.05$).

From 1 to 24 October the three harassed females were encountered outside their home ranges in 15 trials on five, five, and seven occasions, respectively, whereas the two collared, unharassed does were observed within their home ranges. We located each of the three harassed does 28 times from 25 October to 28 November. They were outside their home range five, five, and eight times, respectively, but none of the control females was outside its home range. This difference is highly significant ($\chi^2 = 5.5$, 9 df, $P < 0.001$). Harassed does ran in some instances more than 1.5 km beyond the boundary of their home ranges, a distance equal to the diameter of the home ranges of the females, and in one case a doe stayed away for two days.

In 1981 the three harassed does had four fawns in late summer; in 1982 only one fawn could be attributed to the three does; in 1983 the three does had five fawns. The two unharassed does had three fawns in 1981, one each in 1982, and three in 1983. In 1981 we saw unmarked females with zero, one, two and three fawns on 8, 105, 47 and 3 occasions, respectively (163); in 1982 the numbers were 2, 34, 11, 0 (47) and in 1983 they were 1, 28, 9, 0 (38). There were no differences among categories between years ($\chi^2 = 1.98$, df = 4, $P > 0.05$). The probability of three does producing one young is based on the proportions of unmarked does with zero, one, two and three fawns [$P(0 \text{ fawn}) = 11/248 = 0.0443$; $P(1 \text{ fawn}) = 167/248 = 0.6734$; $P(2 \text{ fawns}) = 67/248 = 0.2702$; $P(3 \text{ fawns}) = 3/248 = 0.0121$]. The probability of one fawn being produced by three unharassed does is $3 [P(0) \times P(0) \times P(1)] = 3 \times 0.0443 \times 0.0443 \times 0.6734 = 0.00396$. Thus, the probability of the three harassed does producing only one fawn, given normal circumstances, is 1 in 253 cases.

Discussion

The results of this experiment on harassment follow expectations in every instance; the capture and handling of the deer affected neither the habituation nor the behavior and reproduction of

two control females. All deer habituated to the ATV travelling along a predictable route. Even when the ATV departed from the predictable route of travel, the habituated deer continued to ignore it; nor did the behavior of harassed companions and their flight through the study area affect the deer we did not pursue. This implies that deer will habituate to and ignore motorized traffic provided the deer are not pursued. Big game readily accept traffic at very close range, as can be seen in national parks and other areas with no hunting (Geist 1971). Only deer pursued by the ATV responded with noticeable behavioral and reproductive changes.

As expected, the harassed females, but not the other females, shifted feeding into darkness, used cover more frequently, left their home ranges more often, and increased flight distances from the ATV. In the following year the three harassed females collectively raised one fawn, having had normal reproduction the year before and the year after. Neither the unmarked does nor the two control radio-collared females suffered decreases in reproduction during the study.

The reproduction depression we observed in harassed deer was highly unlikely to occur by chance alone, and may well be representative despite the small sample size. The harassed does behaved as expected and were reliable in the behavioral changes they exhibited. We conclude that deer "addressed" by a harassing stimulus suffer significant disruptions in their biology.

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Cherry Depredation by Ring-billed Gulls, *Larus delawarensis*, in the Niagara Peninsula, Ontario

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Blokpoel, H., and J. Struger. 1988. Cherry depredation by Ring-billed Gulls, *Larus delawarensis*, in the Niagara Peninsula, Ontario. *Canadian Field-Naturalist* 102(3): 430–433.

In 1985, for the first time, Ring-billed Gulls, *Larus delawarensis*, landed in trees to eat cherries in the Niagara Peninsula, Ontario. At six Ring-billed Gull colonies in the Niagara Peninsula area, an estimated total of close to 1 200 000 regurgitated cherry pits was found. Based on a retail value of 2 cents per cherry and on the assumption that all these pits were taken from orchard trees in 1985, these pits represented a loss of \$23 500 during 1985. A few growers who responded to a questionnaire survey estimated damage at \$3400.

Key Words: Ring-billed Gull, *Larus delawarensis*, feeding, cherries, financial damage, Niagara Peninsula, Ontario.

The diet of the Ring-billed Gull, *Larus delawarensis*, in Ontario is extremely varied, including fish, insects, earthworms, handouts, garbage, and fruits such as tomatoes, strawberries and blueberries (reviewed by Blokpoel and Tessier 1986). Feeding by ring-bills on cherries has been observed in northern New York (Kibbe 1979), but until 1985 this behaviour had not occurred in Ontario, or had not been brought to the attention of the Canadian Wildlife Service.

This report documents observed feeding on cherries by Ring-billed Gulls in 1985, presents findings of counts of regurgitated cherry pits at gull colonies, and provides estimates of the damage to cherries by gulls in 1985 in Ontario.

Methods and Materials

Gulls feeding on cherries

We did not observe gulls feeding on cherries. We were contacted by people who had actually seen gulls eating cherries in orchards and we interviewed them on the phone.

Estimate of financial damage

We estimated the number of regurgitated cherry pits at the following six colonies: the breakwall at Port Colborne, the yards of Hamilton Marine at Port Colborne, Tower Island (in the Niagara River just south of Niagara Falls), the East Port development of Hamilton Harbour, the Stelco Yards at Hamilton Harbour, and Tommy Thompson Park, formerly known as the Eastern Headland of the Toronto Outer Harbour (Figure 1).

To estimate the number of regurgitated cherry pits we counted pits in sample transects. Transects were 0.9 m (a yard) wide and varied in length from

9 m to 37 m ($\bar{x}$ = 24.3 m, N = 47). The number of pits per colony was estimated by multiplying the estimated size of the colony (in m²) and the average number of pits/m² for that colony.

The estimated number of pits was converted to financial loss by using a value of 2 cents per cherry. This value was based on a 1-kg basket of cherries that we purchased on 24 July 1985 at a major grocery store in the Hamilton area. This basket held 150 cherries and cost \$3.10.

Results

Gulls feeding on cherries

The main observations are summarized in Table 1. The typical way of foraging was for a flock of gulls to circle over an orchard. Eventually one or two gulls descended, alighted in a tree and began eating cherries. Soon other gulls would follow their example. While some gulls alighted on branches, other gulls walked on the ground snatching cherries from low branches and picking up fallen cherries.

Although the gulls took both sweet and sour cherries, one grower mentioned that they appeared to prefer sweet cherries. All observers reported that this was the first time they had ever seen gulls feeding on cherries.

Estimate of financial damage

The total estimated number of cherry pits at the six colonies visited was 1 174 000 (Table 2). The average number of pits per m² varied from a high of 35.3 at Stelco (only a few km away from the nearest cherry growing area) to a low of 0.2 at the Eastern Headland (some 50 km away). The highest number of pits on an individual transect was also found at Stelco (57.3 pits/m²).



FIGURE 1. Map of the Niagara Peninsula and vicinity.

Assuming that all cherry pits found at the six colonies were of cherries that would have been sold at 2 cents each if there had been no interference by gulls, the cherry pits found at the colonies represent an estimated retail loss of \$23 480.

Discussion

Gulls feeding on cherries

The comments by the observers suggested that feeding by Ring-billed Gulls on cherries in 1985 was a new, rather than a hitherto unnoticed, activity in Ontario. At the colony sites we also found small numbers of regurgitated pits of plums and peaches. One grower reported that gulls were

feeding on plums in his orchard and that they might also feed on peaches, pears and grapes.

Estimate of financial damage

Our estimate of the magnitude of damage based on estimated numbers of regurgitated cherry pits has several biases:

(1) We did not visit five known colonies in the Niagara Peninsula area: Mohawk Island (in eastern Lake Erie 20 km west of Port Colborne, Figure 1), Stony Point and Donnelly's Pier (at the easternmost tip of Lake Erie near Buffalo), and Buckhorn Island and Table Rock Island (in the Niagara River south of Tower Island). These colonies had an estimated total of 18 500 nests in

TABLE 1. Reports of Ring-billed Gulls feeding in cherry orchards in the Niagara Peninsula, Ontario, in 1985.

Locality (nearest town)	Dates (1985)	Cherry		Comments by observers
		sweet	sour	
Fonthill	10 July	—	—	First time ever. Many gulls circling overhead. After one gull lands in a tree others soon follow.
Grimsby	8-15 July	yes	—	First time ever. Some 150 gulls cleaned out one orchard.
Winona	8-15 July	yes	yes	First time ever. Gulls sat on branches and stood on the ground. Hundreds of gulls, some adults but mostly immatures. Sweet cherries preferred.
Pelham	“during harvesting”	yes	yes	First time in 50 years of cherry growing. Gulls cleaned out trees in few minutes.

1984 (Blokpoel and Tessier 1986). We do not how many pits might have been found at those colonies, but the unvisited colonies represented 27% of the Niagara Peninsula population in 1984.

(2) The gulls regurgitated cherry pits also at other places. Pits were noted in small numbers at the following day-time resting sites: the main parking lot of Brock University, St. Catharines, between 15 and 19 July 1985 (G. Melvin, personal communication); the Burlington Canal Breakwall on 1 August; and the Breakwall of the Canada

Centre for Inland Waters on Hamilton Bay on 14 August. There must have been many other areas where loafing gulls regurgitated cherry pits in 1985.

(3) Not all pits found in 1985 were regurgitated in that year. A few pits had a greyish, weathered look and were probably dropped in previous years. Although we kept no separate count of weathered and fresh pits, we are confident that more than 90% of all pits that we counted were fresh ones, i.e. with a smooth surface and beige-to-pinkish colour. Sometimes bits of cherry skin were still stuck to the

TABLE 2. Estimates of numbers of regurgitated cherry pits at some Ring-billed Gull colonies in the Niagara Peninsula area in the summer of 1985.

Name of Colony	Number of Nests in 1985	Estimated number of cherry pits (to nearest 1000)	Cherry Pit Sampling				
			Date	Number of transects	% of colony covered by transects	Number of cherry pits/m ²	
						mean	range
Breakwall, Port Colborne	1000 ^a	10000 ^d	2 August	0	—	—	—
Hamilton Marine, Port Colborne	48000 ^b	577000	30, 31 July	20	0.4	5.0	1.7-10.3
Tower Island, Niagara River	4000 ^b	2000	30 July	7	5.3	0.8	0.1- 2.8
East Port, Hamilton Harbour	14000 ^b	366000	24 July	6	0.8	14.5	4.5-30.0
Stelco Yards, Hamilton Harbour	5000 ^c	207000	31 July	8	2.7	35.3	20.9-57.3
T. Thompson Park, Toronto.	47000 ^b	12000	1 August	6	0.2	0.2	0.2- 0.4
TOTALS	119000	1174000	—	47	—	—	—

^aEstimate (R. D. Morris, personal communication).
^bNest count.
^cEstimate.
^dEstimate based on 10 pits per nest. Pits were numerous (G. Melvin, personal communication) but could not be sampled because colony is located on large boulders.

pits. In many cases we found bolusses of pits, but most pits were scattered in small loose groups.

(4) Some of the regurgitated pits may have been of wild cherries but we believe that the great majority of them would be of cultivars. Pits of wild and cultivated cherries are virtually impossible to differentiate other than by germinating tests (G. Tehrani, personal communication). The opportunistic ring-bills would presumably avail themselves of conveniently clustered food sources, such as cherry trees in an orchard.

(5) Some of the pits may have been of cherries that were not harvested. Sweet cherries are picked by hand and the pickers usually overlook very few cherries. Sour cherries are picked mechanically and 3–5% of the cherries are missed (J. W. Smith, personal communication). Sometimes cherries fall to the ground before they are picked.

(6) Our damage estimate is based on a calculated value for sweet cherries. Although most growers stated that the gulls preferred sweet cherries, sour cherries were taken as well.

(7) Ring-billed Gulls feed on garbage dumps in southern Ontario and it is possible that some of the regurgitated pits had been picked up at dump sites. There are some 15 cherry canneries in the Niagara Peninsula where sour cherries are depitted before being canned (G. Tehrani, personal communication). The clean pits are dumped in pit disposal areas. It is unlikely that gulls would feed on these pits, especially if ripe cherries were available in the orchards (J. W. Smith, personal communication).

From the above considerations it is obvious that our estimate of \$23 500 damage is crude and incomplete.

Another estimate of gull damage to cherries during 1985 was obtained by C. Baldwin, Ridgetown College of Agricultural Technology, Ridgetown, Ontario, who published a damage questionnaire in *The Grower* requesting growers to report gull damage. *The Grower* is published monthly by the Ontario Fruit and Vegetable Growers Association and mailed to some 10 000 members. Of the 43 questionnaires returned, six reported damage by gulls to cherries for an estimated total of \$3400 (C. Baldwin, personal communication). It is unlikely that all cherry growers with gull damage reported to Dr. Baldwin.

In 1986, when C. Baldwin published his questionnaire again, no growers reported cherry

depredation by gulls. In 1987 no damage survey was undertaken in Ontario, but cherry depredation was probably light because only 11 complaints were received by the Canadian Wildlife Service (J. Sullivan, personal communication).

In New York State cherry depredation was first noted in 1979 (Kibbe 1979) and damage was first reported in 1984 along the south shore of Lake Erie. Since then there have been a few reports each year but cherry depredation problems have been controlled by the use of shell crackers (J. Forbes, personal communication). Cherries are also grown in northwest Michigan and there ring-bills were first reported feeding on cherries in 1984. There were a few complaints in 1985 and 1986, but in 1987 there were no reports of gulls in cherry orchards (G. Dudderar, personal communication). These observations suggest that on the one hand cherries are not an important component of the gulls' diet, but that on the other hand the opportunistic ring-bills may feed substantially on cherries if other food sources are less available or less attractive. Because cherries are not essential for the omnivorous gulls, it is relatively easy to scare them away from orchards where they cause problems.

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Habitat Use, Behaviour and Management of Trumpeter Swans, *Cygnus buccinator*, Wintering at Comox, British Columbia

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Of eight categories of behaviour exhibited by Trumpeter Swans (*Cygnus buccinator*) wintering at Comox, feeding was the dominant activity in daylight periods (37.7% of the time), but sleeping predominated during the night (41.5%) and over the total 24-hour period (36.0%). Feeding on dairy pastures occurred only during daylight and accounted for 74.6% of the time spent there. All behaviours were reducible to two basic types — foraging and resting. On average 57.6% of a given daylight period and 47.2% of a night period were spent foraging on the estuary, while 87.1% of daylight time on dairy pastures was spent foraging. Feeding on the estuary was regulated by tidal conditions. At night there was a slight negative correlation between numbers feeding and temperature. Other environmental factors were not found to be important influences. During grazing on dairy pastures, foraging was more or less constant, with no daily peaks of intensity. Dogs were the most effective method of discouraging swans from grazing on pastures. The provision of alternate food sources is not recommended.

Key Words: Trumpeter Swan, *Cygnus buccinator*, British Columbia, behaviour, management, wintering.

The coast of British Columbia is the winter home of at least half the world's population of Trumpeter Swans, *Cygnus buccinator* (McKelvey 1981a). The estuaries of the numerous creeks and rivers flowing out of the coastal mountains are the habitats most used by swans. In 1977 we began an ecological study of Trumpeter Swans wintering at Comox and Port Alberni, British Columbia. The impetus for the study was the annually increasing number of swans wintering near Comox (49° 40' N, 124° 55' W) and the apparent depletion of estuarine foods. Grazing by swans on surrounding dairy pastures was postulated to be a behavioural response to a diminished natural food supply, but that was not so (McKelvey 1981b). Grazing by swans is now firmly established, and there are conflicts with farmers. In this paper we report how swans use estuarine and agricultural habitats at Comox. We present information on swan behaviour and activity budgeting as an indication of habitat use, analyze factors affecting behaviour, and assess crop depredation by grazing swans. Finally, we suggest ways in which conflicts between farmers and swans can be managed.

Methods

Behaviour and Habitat Use

Behavioural observations were made during 11 days (ca. 0630–1800 h) and four nights (ca. 1800–0800 h) on the estuary at Comox Harbour and during seven days on adjacent dairy pastures in the late winter of 1977–78 and throughout the

winter of 1978–79 (Table 1) for a total of 190 hours. During each observation period (started at intervals of 60 min, 30 min, or 15 min) the flock of swans was scanned from side to side with a 20X telescope in daylight or with a night-vision scope at night. Each scan lasted 1–10 min depending on the number of swans and the difficulty of observation. Behaviour of each bird was recorded as feeding, swimming, walking, preening, sleeping, alert, flying, or agonistic.

In January and February 1978, swans used the Millard Road and Trailer Court (Figure 1) areas of the estuary in equal numbers. Observations were made at 60 min or 30 min intervals from both of those locations. From November 1978 to February 1979 most birds were visible from the Sewage Lagoon (Figure 1). This allowed us to remain at that location most of the day, making observations at 15 min intervals. Inland observations were made at Farquarson's Farms in 1978, and at Beaver Meadow Farms (Figure 1) in 1979. When swans were absent from the estuary, observations on the fields were made every 15 min. When swans were being observed on both the fields and the estuary, observations were made at intervals of 60 min.

Tide heights were calculated from Canadian Hydrographic Service Tide and Current Tables, temperature and wind speeds were obtained from Atmospheric Environment Service records for Comox airport, and snow was noted as present or absent. Other environmental factors noted that could have affected the behaviour of swans

TABLE 1. Percentage of total time of each observation period spent foraging and mean time foraging by Trumpeter Swans on Comox Harbour and adjacent fields.

Location and date	Total hours of observation	Period of observation	Time spent foraging (%)	Snow present on fields
<i>Estuary, daylight</i>				
12 January 1978	9.0	0830-1730 h	50.0	+
19 January 1978	10.5	0730-1800 h	62.0	+
1 February 1978	4.0	1300-1700 h	37.3	+
2 February 1978	9.0	0800-1700 h	65.3	+
15 February 1978	10.0	0700-1700 h	74.8	-
25 November 1978	9.0	0730-1630 h	80.6	-
21 December 1978	10.0	0630-1630 h	43.3	-
4 January 1979	9.5	0730-1700 h	48.0	-
17 January 1979	2.0	1500-1700 h	56.5	-
18 January 1979	10.75	0630-1715 h	41.5	-
7 February 1979	2.5	0715-0945 h	84.9	-
Mean % time spent foraging ($\pm$ SE)			58.6 $\pm$ 4.9	
<i>Estuary, night</i>				
18-19 January 1978	12.0	1830-0630 h	32.2	+
4- 5 January 1979	13.75	1800-0745 h	68.6	+
6- 7 February 1979	13.25	1745-0700 h	40.8	-
7- 8 February 1979	15.5	1615-0745 h	45.0	-
Mean % time spent foraging ($\pm$ SE)			46.6 $\pm$ 7.8	
Estuary night			46.6 $\pm$ 7.8	
Estuary night and daylight combined			55.4 $\pm$ 4.2	
<i>Fields</i>				
25 November 1978	7.5	0830-1600 h	79.7	-
21 December 1978	7.5	0800-1530 h	74.3	-
17 January 1979	6.75	0945-1630 h	86.8	-
6 February 1979	2.5	1430-1700 h	97.9	-
7 February 1979	5.5	1015-1545 h	95.7	-
25 February 1979	9.0	0930-1830 h	81.7	-
16 February 1979	10.75	0730-1815 h	93.6	-
Mean % time spent foraging on fields ($\pm$ SE)			87.1 $\pm$ 3.4	

included loud noises, changing weather conditions, low flying aircraft, and the presence of potential predators such as Bald Eagles, *Haliaeetus leucocephalus*, dogs and people.

The number of birds observed exhibiting each behaviour was expressed as a percentage of the total birds visible. The mean time spent in each behaviour was calculated by measuring the area under the curve of the ethogram produced for each day or night of observation. Linear and non-linear regression analyses (Zar 1974) were used to test for correlations with activity, tide height, and time of day. All behaviours were classifiable into two main types: foraging and resting. We defined foraging as swimming, walking, and being alert when feeding was the dominant activity of the flock. Resting was defined as preening, sleeping, and being alert when sleeping was the dominant activity. Flying and agonistic encounters were not included because they occupied only a few minutes each day.

Grazing Pressure and Management

The amount of food used by swans grazing at the Beaver Meadow Farm was assessed using exclosures. Thirty-four 1-m² exclosures were placed at random on a field used by swans the previous year. Randomization was accomplished by walking to parts of the field and placing an exclosure in the vicinity by an over-the-shoulder technique. That resulted in a uniform placement of exclosures throughout the field and precluded subconscious bias in selection of the actual exclosure sight. Before the swans arrived, an area of 0.25 m² was clipped approximately 5 cm above the ground adjacent to each exclosure. Each sample was dried at 100°C for 24 hours and weighed. Swans were counted at two-week intervals to determine the level of use of the field. After the swans had departed in the spring, the biomass of grass remaining was estimated using 17 of the 34 exclosures. The remaining 17 exclosures

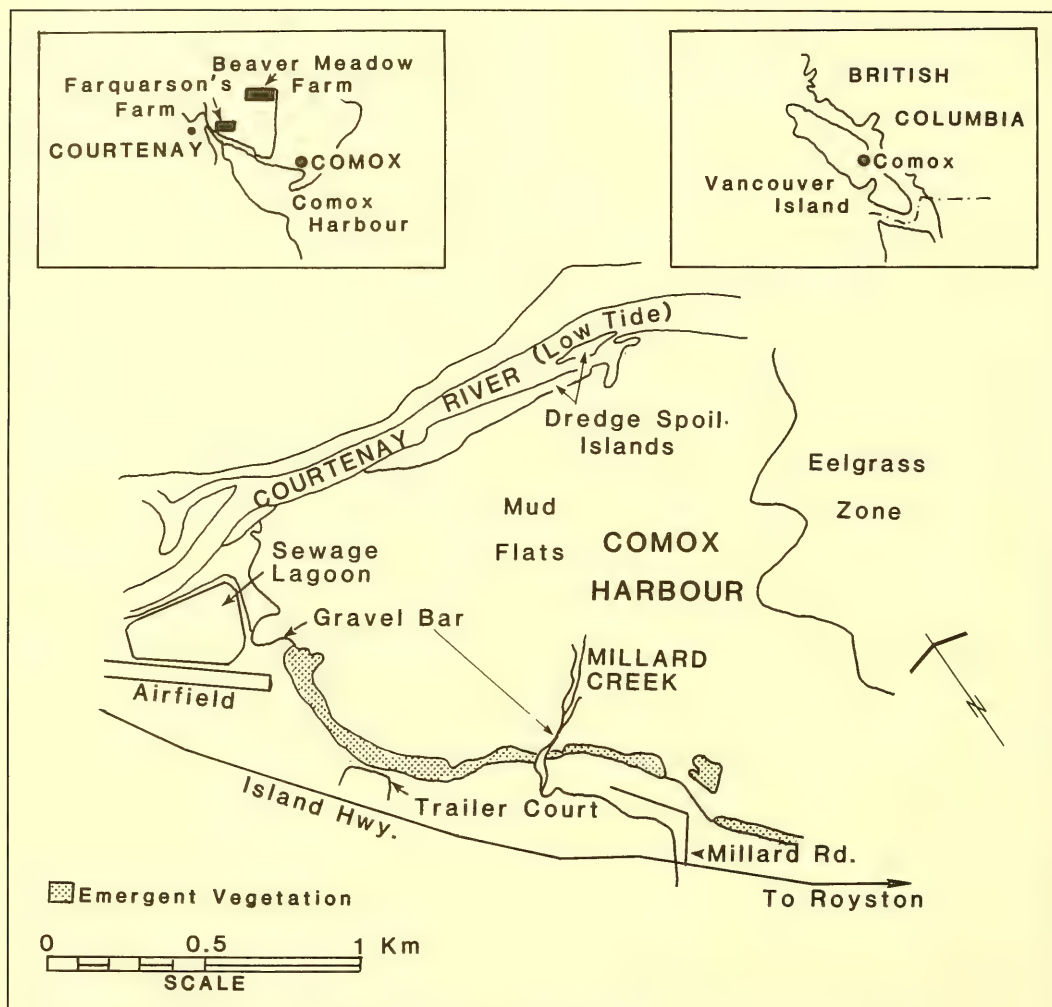


FIGURE 1. Comox study area.

were used for another experiment. An area of 0.25m^2 was clipped in each enclosure and at a random distance outside the enclosure. The amount of grass consumed was calculated by comparing the initial biomass with the final biomass and correcting for growth of the grass during winter.

Shell crackers and shot guns, dogs, and provision of an alternate source of food were tested as means of discouraging swans from grazing on fields. Shell crackers and live ammunition were used to make noise, not to kill birds. Alternate foods were provided by planting Fall Rye, *Secale*

serale, on land normally left fallow over winter. Approximately 40 ha on five different farms were seeded by aeroplane in late August 1982. Aerial application was used because silage corn on most fields had not yet been cut. Ground seeding after corn harvest would have been difficult because of fall rains, and would have been too late for good germination.

Results

General Behaviour and Activity Budget

Feeding Behaviour. Feeding occurred throughout the 24-hour period on the estuary, and

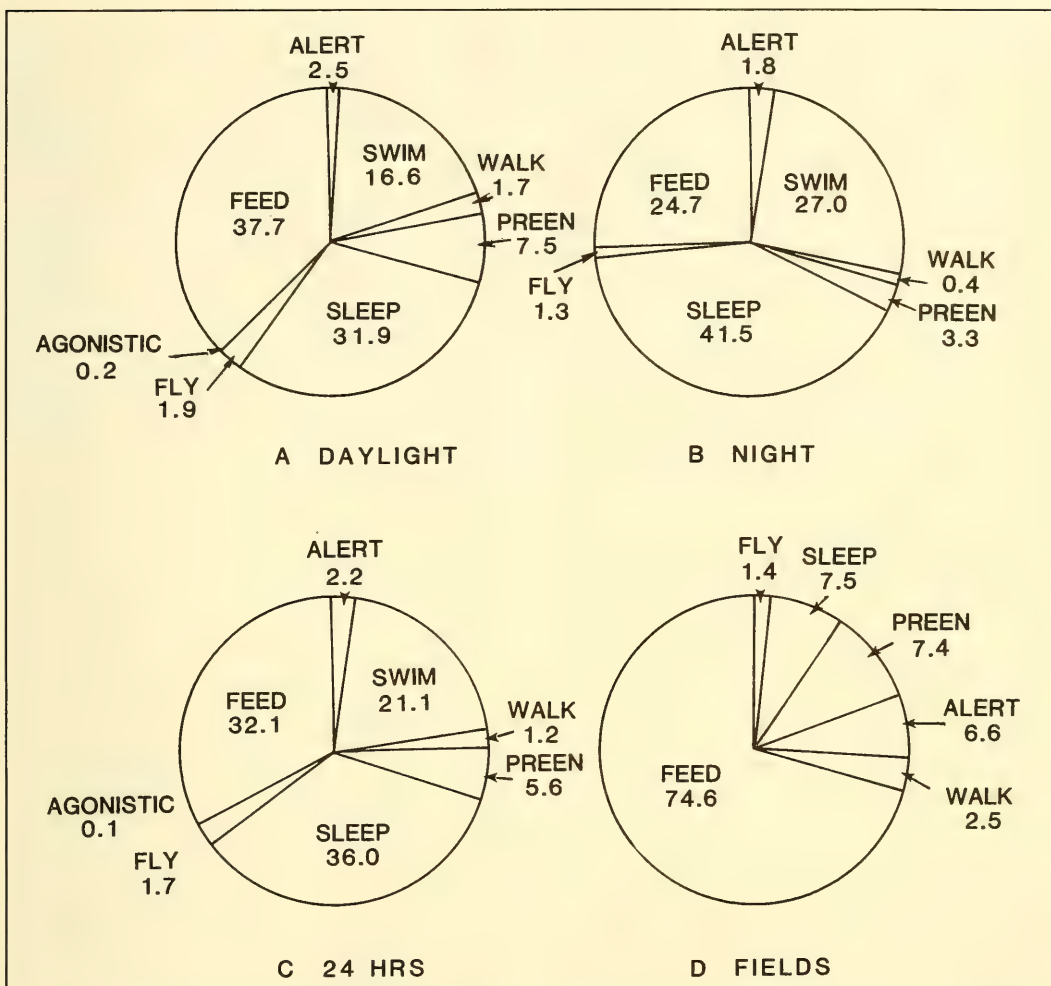


FIGURE 2. Proportion (%) of time spent in various behaviours by Trumpeter Swans wintering at Comox Harbour on the estuary (A-C) and on the fields (D).

accounted for 32.1% of the time spent there (Figure 2). The amount of time spent feeding in daylight was not significantly different from that spent feeding at night ($P > 0.05$). Emergent plants eaten were from a dense mat of roots dominated by Bulrush, *Scirpus americanus*, and Arrowgrass, *Triglochin maritimum* (McKelvey 1981b). Feeding occurred all along the edge of intertidal vegetation, but was most extensive below and south of the Sewage Lagoon and at the foot of Millard Road (Figure 1), where vegetation was abundant and could not be approached easily by humans from the shore. The vegetation at Millard Road was confined to a narrow band along the shore except

for a large, circular patch of almost pure Bulrush that received all the use by swans in that area. The patch was some distance from shore and was not easily approached by predators.

Swans fed on emergent vegetation by pulling up rhizomes with the bill, leaving a depression or crater in the substrate. During low tides the birds stood or sat and extracted rhizomes from the edge of a crater. During high tides they reached the rhizomes by submerging the head while swimming, or by tipping up when the vegetation was deeply covered. In shallow water, swans paddled their feet to loosen the rhizome substrate (*sensu* King 1974). After several seconds of paddling the swans settled

back onto the water, submerged their heads and continued grubbing. If a rhizome was not soon extracted, paddling was repeated. Eelgrass, *Zostera marina*, composed 33.8% of the food eaten by the swans (McKelvey 1981b), and was generally only available at night when exposed by low tides. Feeding was assumed to be by grazing, with little or no grubbing, because of the frequent occurrence of cell fragments in droppings analyzed for food habits (McKelvey 1981b). Swans occasionally picked up Eelgrass leaves along the tide line in daylight.

Swans usually grazed when they were on pastures but occasionally they grubbed for grass roots when there was much standing water. Feeding on fields occurred only during daylight, and accounted for 74.6% of the time spent there (Figure 2). The amount of time spent feeding varied significantly between the estuary and the fields ($P < 0.001$; Figure 2).

Alert Behaviour. Alert behaviour constituted a small portion of the swans' daily activity budgets and was more important on the fields than on the estuary ($P < 0.05$; Figure 2). On the estuary only people and dogs caused the swans to be alert. The appearance of Bald Eagles and the occasional aircraft landing or taking off from the runway near the Sewage Lagoon (Figure 1) did not alarm the birds. The only causes of alertness on the fields were people, or vehicles slowing or moving towards the swans.

Swimming and Walking. Swimming was a major activity on the estuary (Figure 2), but it seldom occurred in the absence of other behaviours. Swimming as a sole activity usually involved only a short distance. Long-distance movements, such as across the harbour, were accomplished by flight. Much less time was devoted to walking than swimming. Walking on the estuary substrate occurred mostly at dusk, when birds which had slept near the shore moved to the water's edge. Walking on the fields was almost always associated with feeding. Birds flying into the field tended to land near the middle and walked in expanding circles toward the edges as the day progressed.

Sleeping and Preening. Sleeping and preening were closely associated. A preening session usually ended when a swan assumed a resting or sleeping position. Sleeping and preening were the dominant activities of swans on the estuary but occupied little time on the fields (Figure 2).

Swans preened and slept at many locations on the estuary but most consistently on gravel bars

near the Sewage Lagoon (Figure 1), at the mouth of Millard Creek, and at the water's edge in the early evening (preening only). They slept on the water at night, with tidal currents often drifting the birds as far as Royston (Figure 1) or into the centre of the harbour. No preferred locations were evident for sleeping or preening when the birds were using the fields.

Flying and Agonistic Behaviour. Little time was devoted to flying (Figure 2). Flights to and from adjacent pastures occurred near dawn and dusk, while flights at other times of the day were rare. Flights were short due to the proximity of the fields to the estuary. Occasionally birds flew into the estuary well after dark, presumably returning from fields some distance away. Birds usually moved in pairs, families or small groups of apparently mature but unpaired individuals.

Agonistic encounters, although seen infrequently (Figure 2), were of three main types. The least frequent but most overt involved vocal threats and wing displays. The common, single-note trumpet call that formed the background "conversation" in most groups was broken by a series of staccato trumpets produced by one or both antagonists. Wing displays usually followed, with a short chase on land, or pecking at the opponent's wings when on water. One of the combatants then usually swam or walked quickly away, shook its tail and adjusted its feathers.

The other two types of encounters were much more subtle, and may often have gone unnoticed. The more aggressive of those involved a peck on the back or wing of an interloper, usually by the larger bird of a family group. The least aggressive encounter involved the simple displacement of one feeding bird by another.

Combined Activities. The amount of time devoted to foraging on each date of observation varied considerably on the estuary, but was relatively constant on the fields (Table 1). On average, 58.6% of the daylight period on the estuary and 87.1% of the time on the fields was spent foraging. The proportion of time spent foraging on the estuary in a 24-hour period was 55.4%.

Factors Affecting Regulation of Feeding Behaviour. Tide height was the main regulator of feeding behaviour on the estuary. Daylight tides were divided into those that were highest in the early morning and dropped throughout the day (Type A tides) and those that peaked near 1200 h and were moderately high all day (Type B tides). During Type A tides the number of swans foraging

was correlated with tide height ($r = 0.77$, $P < 0.01$). During Type B tides the number of swans foraging was less well correlated with tide height ($r = 0.40$, $P < 0.05$). Numbers of swans foraging on days of Type A and Type B tides were negatively correlated with time of day ($r = -0.73$, $P < 0.01$; $r = -0.51$, $P < 0.01$).

Average number of birds foraging was largest at the time of high tide; thus, foraging was not influenced by sunrise and sunset times. Number of swans foraging at night was positively correlated with tide height ($r = 0.78$, $P < 0.01$). Most observations at night were made when swans fed over emergent vegetation. Feeding on Eelgrass could have occurred over a larger portion of the night than we were able to detect, because the birds were too far from shore.

Overall levels of disturbance at Comox were low and there were no obvious correlations between numbers of swans foraging and potential sources of disturbance such as predators, low flying aircraft, and other loud noises. Other factors, such as the presence of snow on fields, similarly had little effect on the proportion of time spent foraging on the estuary (Table 1).

Temperatures during the study period ranged from -7 to $+7^{\circ}\text{C}$. Wind was usually light (under 10 km/h), reaching a high of 20 km/h only once. No strong correlations were found between time spent foraging and air temperature or wind speed except at night when there was a slight negative correlation with temperature ($r = -0.52$, $P < 0.01$).

No factors were found to influence feeding on the fields. Darkness and snow cover precluded field use, but when fields were available feeding was more or less continuous.

Grazing Pressure and Management

High levels of use by swans has resulted in the perception of a depredation problem by farmers. The field used for the grazing study received approximately 266 swan-use days/ha over the winter of 1979–80. That level of use resulted in the removal of $326.0\text{ kg dry matter/ha}$ ($\text{SE} = 112.6$, $n = 17$), or about $1.2\text{ kg dry matter/swan-day}$ ($\text{SE} = 0.4$).

A dog was the most effective means of deterring field use by swans. A dog covered a larger area more quickly than a person on foot and swans reacted much more quickly to a dog than to a person approaching. To be most efficient, a dog had to be directed to chase all groups of swans present so that all became airborne. Any birds that remained on the field attracted those in the air to settle again. Once a field had been cleared of swans, they usually did not return that day. When the

procedure was repeated daily for several weeks, the number of swans returning was reduced from about 300 to 50, a number acceptable to the farmers. Shell crackers and live ammunition were effective for a short time and over a short range. Both required approach on foot to within approximately 50 m of the birds. After experiencing the noise several times, only the nearest birds took flight. The procedure had to be repeated many times if a large number of birds was present, as the first swans to leave rejoined those remaining behind.

The provision of alternate food was only marginally successful. Rye seeded in areas where corn had already been harvested produced a biomass of $3.1\text{ g dry matter}/0.25\text{ m}^2$ ($\text{SE} = 0.6$, $n = 8$) by March, not significantly different ($P > 0.05$) from the yield on areas seeded before the corn was harvested ($4.6\text{ g dry matter}/0.25\text{ m}^2$, $\text{SE} = 1.0$, $n = 14$). With some adjustments in the timing of seeding, better production seems likely. Unfortunately, swans made little or no use of newly germinated Fall Rye; the reason is not clear, but may be related to extensive pastures available in the Comox area. This part of the study took place during a year in which swans did not concentrate in large flocks as they did in previous winters. Instead, they fed in groups of 25 to 50, numbers which did not cause farmers much concern and resulted in relatively low levels of harassment.

Discussion

The diet of estuarine plants and the use of habitat at Comox Harbour are probably typical of Trumpeter Swans elsewhere on the Pacific coast during winter. The influence of tide levels on feeding behaviour has been observed in other species of waterfowl. In most cases, food was unavailable because it was too deeply covered at high tide (Ranwell and Downing 1959; Burton and Hudson 1978) or it was impossible to remove adhering silt at low tide (Burton and Hudson 1978). Swans wintering at Comox apparently responded to water depths over their food. Foraging was most intense on days of Type A tides, when emergent plants were covered by only about 30 cm of water, apparently an ideal depth for feeding. A lower correlation between numbers of swans foraging and Type B tides reflects small tidal fluctuations on those days. As emergent vegetation was partially or completely covered most of the time, some level of foraging was possible for most of the day.

Feeding craters were similar to excavations made by other species of swans. Some workers,

however, have concluded that the craters are made by a scratching and clawing motion of the feet (Owen and Kear 1972; Shea 1979); that was not the case in this study.

The areas that offered the best protection from approach by land, at least at night, were most heavily used for sleeping and preening. The apparent lack of aerial or aquatic predators was shown by the way the swans were dispersed in the centre of Comox Harbour while sleeping at night. If predation had been a potential problem, the birds might have stayed closer together rather than drifted passively with the tides.

Use of dairy pastures has not been a response to a loss of traditional habitat at Comox or elsewhere on the coast. However, pastures are now an important food source, as shown by the number of swans using them and the time spent foraging there each day. Similar levels of use have been reported for Barnacle Geese, *Branta leucopsis*, (82.5%, Ebbinge et al. 1975) and White-fronted Geese, *Anser albifrons*, (90%, Owen 1971). Pasture grass was much higher in protein (22.9%) than were the estuarine plants (7.0%; McKelvey 1981b), but much less digestible, as shown by the many whole leaves seen in droppings. The much longer time spent feeding on pastures was probably a compromise between those two factors. Because we could not identify individual birds we could not tell if birds that fed on fields during the day also fed on the estuary at night. In 1980 some swans remained on fields throughout the night but they did not feed then (E. Smith, personal communication). Birds which remained on the estuary throughout the day or which could not graze on fields because of snow cover are assumed to be the birds we saw feeding at night on the estuary.

The amount of food consumed on pastures seems high. Assuming a 75% moisture content, the wet weight of grass used by a 10-kg swan amounted to 36%–73% of body weight per day. Owen (1972) reported White-fronted Geese consumed 28%–35% of their body weight in grass per day. Ebbinge et al. (1975) estimated Barnacle Geese consumed 40%–46% of their body weight per day while grazing. Grass may be very poorly metabolized by swans (McKelvey 1985). If swans are less efficient than geese at using grass, even though swans are larger, our estimate is at least within the ranges of those reported for geese.

Why swans began to use pasture grass is unclear, but a combination of factors seems likely. Wet fields near the estuary probably attracted swans initially. The open nature of the fields, with some standing water, resembles conditions on the

estuary. The nutrient value of pasture grass and the comparative ease with which it could be eaten quickly made it more attractive than the emergent plants.

The rate of increase of swans near Comox is much greater than that of the total world population of this species. A peak population of about 1000 birds occurred at Comox in 1984–85 (R. Rogers, personal communication), double the number seen there in 1978–79 (McKelvey 1981b). Comox is an attractive wintering area for swans, probably because of extensive food resources and its position relative to the swans' migration route. Resightings of birds neck-collared in Powell River, British Columbia, indicate an interior migration route with egress to the coast via the mainland inlets Knight, Bute and Toba (McKelvey and Burton 1983). Swans following the interior route will arrive at Comox, which may be the first major area of wintering habitat they encounter.

The most effective method of keeping swans away from pastures on which they are not wanted is the use of trained dogs. Alternate sources of food may be an option but harassment in areas where swans are not wanted would still be necessary. In the long run, the provision of an alternate upland food may not be desirable because it requires an annual investment, which may currently be difficult to justify. The world population of Trumpeter Swans is increasing at an annual rate of 10% (King and Conant 1983). If it continues to do so, the most effective management technique may be to force the birds to make use of natural habitats, or at least to make less intensive use of pastures.

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Parasitic Fungi of Newfoundland Based on Specimens from Gros Morne National Park

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Parmelee, J. A. 1988. Parasitic fungi of Newfoundland based on specimens from Gros Morne National Park. *Canadian Field-Naturalist* 102(3): 442-464.

One hundred and thirty species of mainly obligate, plant-parasitic fungi are recorded for Newfoundland-Labrador. Thirty-four taxa are new for the province and these are so indicated along with observations on hosts, morphology and distribution in Newfoundland and elsewhere in Canada.

Key Words: Parasitic fungi, rusts, smuts, mildews, leaf spots, Newfoundland.

In late July and early August of 1983, parasitic fungi on vascular plants were collected in Gros Morne National Park, Newfoundland. These collections, supplemented with specimens from other areas of Newfoundland on deposit in the National Mycological Herbarium (DAOM), Ottawa, form the basis for this report.

The Biosystematics Research Centre established surveys for plants, fungi and insects in the national parks of Canada in 1975 as a service for Parks Canada and as a means of augmenting collections from diverse regions of the country. To date, the parasitic fungi have been reported from St. Lawrence Islands National Park in Ontario, Kouchibouguac National Park in New Brunswick, Riding Mountain National Park in Manitoba, and Waterton Lakes National Park in Alberta (Parmelee 1984). All specimens reported here are on deposit in the National Mycological Herbarium, Ottawa (DAOM).

Study Area

Gros Morne National Park occupies 750 square miles between latitudes 49°15'N and 49°58'W on the west coast of the Long Range Peninsula. From the coast it extends irregularly inland about 40 km (25 miles) at the widest point. Most of the Park area is occupied by the plateau of the Long Range Mountains, but a coastal plain, 4-8 km wide, extends north of Bonne Bay. Many small rivers which cross the plain drain a number of fiord-like, but land-locked, lakes that extend well into the Long Range Mountains (Figure 1).

The mountain tops are mainly treeless (Figures 2 and 5), but support a variety of scattered herbaceous plants (*Ledum*, *Sanguisorba*, *Myrica*, *Carex*). As one descends towards the plain, plant growth and number of host species increase (Figure 2), passing through shrubby needle-leaf

trees with patches of ericaceous plants into spruce-fir boreal forest (Figures 4 and 7) and finally at the plain into grassland, bog and gravel ridge plant associations (Figure 6). The plains flora is somewhat more complex and has been treated in detail by Bouchard and Hay (1976).

Plant names are mainly those used by Fernald (1950), but it would be remiss not to draw attention to the published account of a trip by W. E. Cormack in 1822 (Bruton 1928) across the Island of Newfoundland (Random Sound to St. Georges Harbour some 300 miles on foot) in which Cormack refers to numerous plants encountered on the journey. Bruton has appended a classified list of the plant names transposed from the common name to the accepted botanical name of the day.

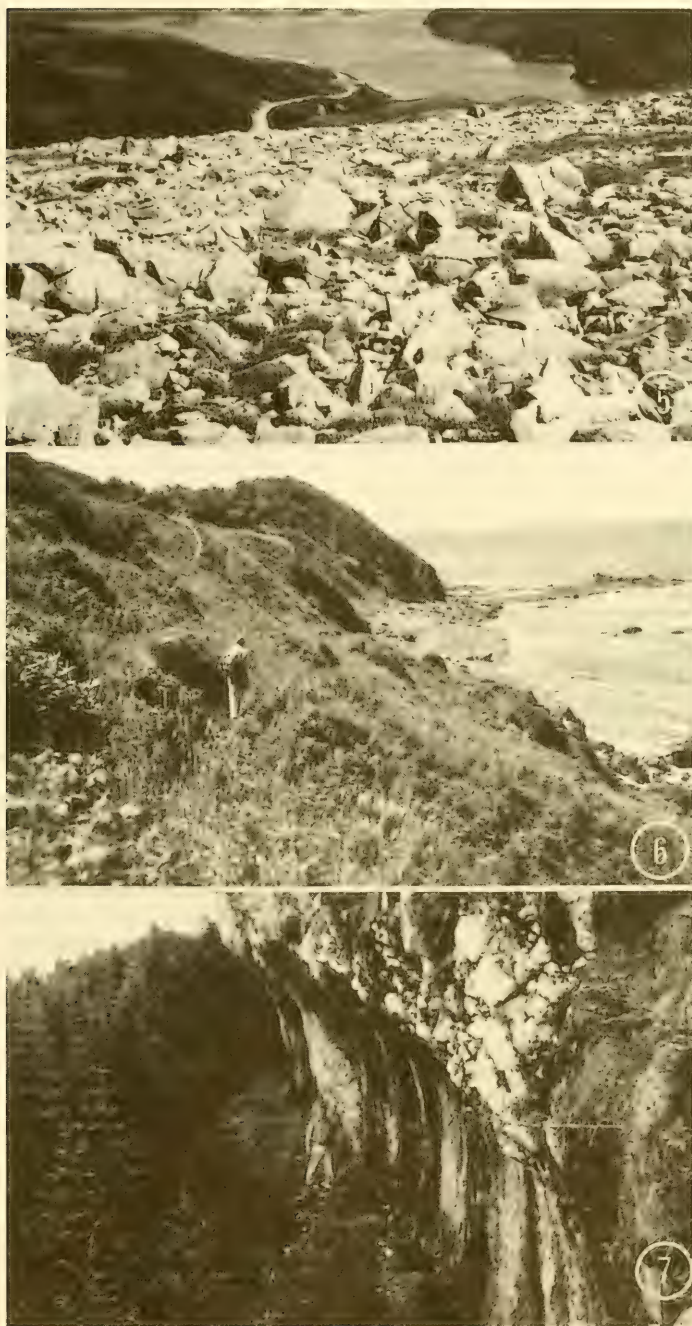
Throughout this text, the name A. C. Waghorne will be encountered occasionally. Waghorne collected Newfoundland plants and fungi in the latter part of the 19th century. His are some of the first fungus specimens taken from the Island. Waghorne's 25 years as a mission priest in Newfoundland have been summarized by Brassard (1980).

Format

The species of parasitic fungi treated here number 130 of which 34 are new for Newfoundland. About half of this total are rusts (57) and smuts (14), both groups of obligate parasites. The species are treated alphabetically within their major taxonomic groups. The general appearance of these major groups is briefly described with short mention of the critical morphological characters. An asterisk denotes new records for the province based on information in Connors (1967), Singh and Carew (1973) and some specific treatments, e.g. *Exobasidium* (Savile 1959).



FIGURES 2-4. (2) Collecting rust on knee-high spruce below the treeless top of Gros Morne Mountain (cf. Figure 3). (3) Yellowed, current-year growth of *Picea glauca* caused by aecia of *Chrysomyxa ledicola* (close-up of Figure 2). (4) Shallow Bay Campsite, site of *Pucciniastrum goeppertianum*; telia on *Vaccinium*; note dark thickened stems (arrows) and aecia on yellowed, current-year needles of *Abies* (arrowheads).



FIGURES 5-7. (5) Table Mountain, treeless top, with Woody Point in the distance, site of *Exobasidium karstenii* on *Andromeda glaucophylla*. (6) Green Garden Trail at coastline, site of *Puccinia coronata* on *Shepherdia canadensis* and *Erysiphe polygoni* on *Ranunculus acris*. (7) Cliffs at Cow Head lighthouse, site of *Puccinia bistortae* and *Bostrichonema polygoni* on *Polygonum viviparum*.

Following fungus and host names, collection data of specimens from the Park and elsewhere in the province are given, including the accession numbers for specimens in the National Mycological Herbarium (DAOM) or duplicates received from the Cryptogamic Herbarium of the University of Toronto (TRTC). Collection sites listed as numerals by Singh and Carew (1973) for stem and needle rusts of conifers or foliage fungi of broadleaf trees, for example, have not been included here. Finally some general comments relative to the fungus, its life cycle, spore characters, distribution, pathology or illustration follow.

General Observations

One of the most obvious parasites in the park was *Chrysomya ledicola* on *Picea glauca*. Along the trail to western Brook Pond and below the peak of Gros Morne Mountain current-year needles throughout large stands of *Picea glauca*, hardly more than knee-high, were conspicuously chlorotic resulting from the high incidence of aecia (Figures 2 and 3). *Ledum groenlandicum*, the alternate and telial host, was abundant throughout these stands of dwarfed spruce. Conspicuous but much less abundant were the elongated brooms on *Abies balsamea* caused by the rust *Melampsorella caryophyllacearum*. The alternate hosts *Stellaria* and *Cerastium* spp. were not seen in the vicinity of such rusted Balsam Fir in the Park, but as the brooms are perennial, they are conspicuous year after year once infection has been established. Also on *Abies*, similar in abundance to the fir broom rust, was *Pucciniastrum goeppertianum*. It is not nearly so conspicuous, however, on the fir, as it is mainly the low level, current-year needles that become locally rusted and chlorotic (Figure 4, arrowheads). Infection stems from nearby *Vaccinium* spp., low-level plants, whose stems become thickened and broomed due to the telial producing, systemic and perennial mycelium (Figure 4, arrows). These are examples of tree rusts common throughout Canada. The alternate hosts were usually present.

In like manner, the *Gymnosporangium* rusts on *Juniperus communis* and *Amelanchier* spp. are Canada-wide in distribution; *G. nidus-avis* on *J. horizontalis* and *Amelanchier* has like distribution but is recorded here for the first time in Newfoundland, probably because the juniper is not common and the rust on the June berry is not readily distinguished from the other *Gymnosporangium* species that attack it. *Puccinia bistortae* on *Polygonum viviparum* alternating to *Conioselinum*

and *Ligusticum* spp. is found at exposed locations in Newfoundland (Figure 7) and elsewhere in Canada at higher altitudes (British Columbia and Alberta) and latitudes (Northwest Territories) but not, or rarely, in southern Canada.

The presence of cupulate aecia on *Taraxacum officinale* identifies the rust to be *Puccinia variabilis*, of limited occurrence in eastern Canada, and not the very common *P. hieracii* of world wide distribution on dandelion and related plants. *Puccinia porphyrogenita* completes its shortened cycle, telia only, on the boreal forest inhabitant *Cornus canadensis*; it occurs in Newfoundland westward across the northern regions of the provinces and the Northwest Territories to British Columbia and the Yukon. The leaf-spotting hyphomycete *Glomopsis corni*, also on *Cornus canadensis*, has a like distribution and is often present on rusted leaves as a second parasite. The Coelomycete fungus *Septoria increscens* on *Trientalis borealis* is now known from Manitoba eastward, but *Trientalis* occupies habitats in the Great Lakes - St. Lawrence forest zone as well as in boreal sites. The known range of the fungus is somewhat more southern than that of *Glomopsis corni*.

In 1983 collecting was done in mid-summer ahead of the peak time for powdery mildews; hence, some of the mildews on tree foliage reported by Singh and Carew (1973), e.g. *Podosphaera clandestina* on *Amelanchier* and *Uncinula adunca* (as *U. salicis*) on *Salix*, were not seen. Mildews are generally more conspicuous and mature in late summer and fall.

The Parasitic Microfungi

CHYTRIDIALES

These are obligate parasitic fungi which lack filamentous mycelium and reproduce by flagellated single-celled swarm cells requiring free water. Infected plants regularly exhibit small wart-like swellings.

Synchytrium endobioticum (Schilb.) Perc. on *Solanum tuberosum* L., [black wart of potato], Regina, Colinet Island, St. Mary's Bay region, DAOM 23818. This fungus is widespread in Newfoundland and is the reason for the ban on the movement of potatoes from there to mainland Canada. A summary of potato wart in Canada is given by Connors (1967) and current research is reported by Hampson (1981).

PERONOSPORALES

These are important plant pathogens with mainly aerial conidia and conidiophores (anormorphs) supported by filamentous hyphae lacking septations, within the host tissues. The sexual

states (teleomorphs) are also buried in the host tissue. Infection results in chlorosis and wilting.

Albugo cruciferarum S. F. Gray [white rust of crucifers] on *Cochlearia tridactylis* Banks, Englee, 1 Aug. 1951, DAOM 55020; on *Draba incana* L. Englee, 1 Aug. 1951, DAOM 42040; on *D. hirta* L., St. Anthony, 17 July 1951, DAOM 55029; on *D. norvegica* S. F. Gray, Englee (S. of St. Anthony), 1 Aug. 1951, DAOM 144768. As the technical and common names of the fungus suggest, numerous plants in the Brassicaceae (Cruciferae) may become parasitized.

Albugo lepigoni (deBary) Kuntze on *Spergularia canadensis* (Pers.) D. Don, Goose Bay, Labrador, 17 July 1949, DAOM 23994.

Peronospora americana Gaum. [downy mildew] on *Polygonum allocarpum* Blake, St. Anthony, 30 Aug. 1951, DAOM 55715.

Peronospora cakiles Savile on *Cakile edentula* (Bigel.) Hook., shallow Bay, 25 July 1983, DAOM 193620. This species was described from coastal Nova Scotia and is known also from coastal St. Lawrence River near Quebec City. Infection causes a general chlorosis.

Peronospora parasitica (Pers.:Fr.) Fr. [downy mildew of crucifers] on *Draba incana* L., Englee, 2 Aug. 1951, DAOM 42043; on *D. norvegica* S. F. Gray, Englee, 2 Aug. 1951, DAOM 144773. As in the white rust above, many genera in Brassicaceae may be attacked and often both fungi occur together on the one host. Collections (DAOM) are from throughout Canada.

HYPHOMYCETES

May be saprophytes or obligate parasites with aerial conidia and conidiophores and are often the anamorphs of Ascomycetes and sometimes Basidiomycetes

Bostrichonema polygoni (Ung.) Schröt. on *Polygonum viviparum* L., [leaf spot] Cow Head, 25 July 1983, DAOM 193587; St. Anthony, 14 June 1951, DAOM 45807. Conidia appear on the underside of irregularly shaped spots and are hyaline, broadly ellipsoid and 1-septate. The infected foliage regularly also bears the rust *Puccinia bistortae* as in the specimens from Cow Head (Figure 7).

Cercospora varia Peck on *Viburnum trilobum* Marsh., Callaghan Tr., 20 July 1983, DAOM 193588. The fungus appears on the undersurface of conspicuous, dark $\pm$ circular leaf spots as clumps of aerial growth. Not previously recorded from Newfoundland but widely distributed on other *Viburnum* spp. in Canada.

Glomopsis corni (Peck) Henderson on *Cornus*

canadensis L., Gros Morne Mtn., 20 July 1983, DAOM 193589; Callaghan Tr., 20 July 1983, DAOM 193590; Lobster Cove Head, 16 July 1983, DAOM 193591; Shallow Bay, 25 July 1983, DAOM 193592 Berry Hill Campground, 17 July 1983, DAOM 193274b. The fungus fruits on the underside of conspicuous, red-rimmed, circular leaf spots as a white granular growth. Although not previously recorded from Newfoundland, its presence was anticipated as the fungus occurs widely across Canada with the host (Parmelee, 1983). See also the rust *Puccinia porphyrogenita*.

Isariopsis bulbigera (Fuekel) Savile on *Sanguisorba canadensis* L., Table Mtn. SW of Woody Point, 28 July 1983, DAOM 193593 [microconidial state]; 8 km N of Port-aux-Basques, 7 Aug. 1963, DAOM 115237 ex TRTC 40771. Conspicuous purple-red spots on the upper surface of leaves are less conspicuous on the lower surface where the fungus fruits. Savile (1957) recorded the first Canadian record from Nova Scotia and provided description and comments on the nomenclature.

Ramularia destructiva Phill. & Plowr. on *Myrica gale* L., Table Mtn. SW of Woody Point, 28 July 1983, DAOM 193596; trail to Bakers Brook from Berry Hill, 31 July 1983, DAOM 193597. Tufts of white conidia appear on the undersurface of necrotic, circular, leaf spots. In earlier fungus floras (Bisby et al. 1938; Wehmeyer 1950) this species was reported as *Ovularia destructiva* (Phill. & Plowr.) Massee. It is known to occur also in British Columbia, Manitoba, Ontario, Nova Scotia and New Brunswick.

Ramularia heraclei (Oud.) Sacc. on *Heracleum lanatum* Michx., Berry Hill Campground, 17 July 1983, DAOM 193598. Conspicuous necrotic leaf spots of variable size are surrounded by conspicuous chlorotic tissue and the fungus appears as a white wooly growth on the underside of the necrotic spots.

Ramularia magnusiana (Sacc.) Lindau on *Trientalis borealis* Raf., Callaghan Tr., 20 July 1983, DAOM 193600; trail to Green Garden, 1 Aug. 1983, DAOM 193599. The irregular and diffuse leaf spots give rise to a white fungus growth from the upper surface. Reported also from Manitoba by Bisby et al. (1938).

Ramularia nemopanthis Clinton & Peck on *Nemopanthus mucronata* (L.) Trel., Berry Hill Campground, 17 July 1983, DAOM 193657(a). Pale chlorotic spots are more conspicuous on the underside of the leaves by the white aerial fruiting fungus. Leaves were also infected with the black tar spot fungus *Rhytisma prini*.

Ramularia vaccinii Peck on *Vaccinium ? pennsylvanicum* Lam., Bishops Falls Ferry, Hy. 1., E of Badger, 5 Aug. 1953, DAOM 40187. This is the only record in DAOM.

COELOMYCETES

The species reported here are all parasitic and cause conspicuous leaf spots. Some species have known teleomorphs in the Ascomycetes; many are unconnected. Conidia arise from a stroma which may often form as a partial or a complete surrounding protective tissue.

Ascochyta pisi Lib. on *Lathyrus japonicus* Willd., Bakers Brook, 21 July 1983, DAOM 193627. It causes a leaf and pod spot of Fabaceae: *Lathyrus*, *Lupinus*, *Pisum* and *Vicia* spp.; serious losses to the pea crop in eastern Canada have been reported (Connors 1967).

Cylindrosporium leptospermum Peck on *Aralia nudicaulis* L., Shallow Bay Campsite, 25 July 1983, DAOM 193602; trail to Western Brook Pond, 22 July 1983, DAOM 193601. The pycnidia are scattered on the underside of large necrotic and irregularly shaped areas. Infection is first conspicuous as large chlorotic patches bearing pale immersed pycnidia (193601), all soon darkening.

Marssonina potentillae (Desm.) Magn. on *Potentilla anserina* L., near Beachy Point, Deer Arm, Bonne Bay, 30 July 1983, DAOM 193603. The fungus sporulates on the upper surface of large irregular necrotic spots.

**Marssonina potentillae* (Desm.) Magn. var. *tormentillae* Trail, on *Rubus chamaemorus* L., Berry Head Pond, 19 July 1983, DAOM 5806. This is a new host species for North America. To my knowledge known additionally only on *Rubus pubescens* Raf. in Wisconsin (DAOM ex WIS). Leaf spots are numerous, small and circular, bearing the fungus on the upper surface.

Marssonina sennensis Gonz. Frag. on *Sanguisorba canadensis* L., Rocky Harbour, 17 July 1983, DAOM 193613; Gros Morne Mtn. alt. ca. 2000 ft. (610 m), 20 July 1983, DAOM 193606; Berry Head Pond, 19 July 1983, DAOM 193605; Rocky Barachois Brook, East Arm, Bonne Bay, 30 July 1983, DAOM 193614. Previously known in Canada from Nova Scotia to British Columbia but represented in DAOM by only three other collections.

Phleospora aceris (Lib.) Sacc. on *Acer rubrum* L., trail to Bakers Brook from Berry Hill, 31 July 1983, DAOM 193665, see also *Rhytisma punctatum*; *A. spicatum* Lam., Lomond, 7 Aug. 1953, DAOM 40196. Specimens in DAOM have been collected also on *A. saccharum* L. and on both hosts from Ontario eastward.

Phyllosticta ? fragaricola Desm. & Rob. on *Potentilla anserina* L. mouth of Bakers Brook, 21 July 1903, DAOM 193615. Necrotic leaf tips support the black pycnidia on the upper surface. This species was described on *Fragaria* (fide Saccardo 1884:40) and spore size given compares favourably with that found for 193615. *Phyllosticta potentillae* Sacc. and *Ph. anserinae* Tehon have narrower spores; no spore measurements were available for *Ph. argentinae* Desm. Saccardo (1884) recorded the last two species on *Potentilla anserina*.

**Septoria canadensis* Peck on *Cornus canadensis* L., Berry Hill, 31 July 1983, DAOM 193616; Cartyville, St. Georges Bay, 7 Aug. 1949, DAOM 40532. Large, irregular necrotic spots bear the fungus on the upper surface.

**Septoria cornicola* Desm. on *Cornus stolonifera* Michx., Berry Hill Campground, 17 July 1983, DAOM 193617; trail to Bakers Brook, 31 July 1983, DAOM 193619. The circular spots are surrounded by purple discolouration and the fungus appears on the upper surface in the centre of the spot.

**Septoria increscens* Peck on *Trientalis borealis* Raf., Berry Hill, 31 July 1983, DAOM 193618. The pale brown leaf spots are characteristic of this fungus which is represented in DAOM from Winnipeg, Manitoba, eastward.

Septoria ribis Desm. on *Ribes* spp., see *Mycosphaerella ribis*.

TAPHRINALES

These fungi cause leaf and fruit malformations usually associated with discolouration of the infected tissue. The fungus forms asci, bearing ascospores within, naked on the affected part.

**Taphrina carnea* Johanson on *Betula papyrifera* Marsh., talus of Gros Morne Mtn., alt. ca. 1250 ft. (381 m), 20 July 1983, DAOM 193634. Asci appear on the upper side of small, yellow leaf blisters. The fungus is known (DAOM) on this and other species of *Betula* from across Canada, including *B. pumila* L., St. Anthony, July 1951 DAOM 28714, 28715.

Taphrina robinsoniana Giesenh. on *Alnus rugosa* (Du Roi) Spreng. Berry Head Pond, 19 July 1983, DAOM 193636; trail to Western Brook Pond, 22 July 1983, DAOM 193635. Long, tongue-shaped malformations which bear the asci protrude from the catkins. Widely distributed in eastern Canada. *Taphrina alni* (B. & Br.) Gjaerum (= *T. amentorum* (Sadob.) Rostr.) produces similar symptoms on *Alnus* spp. in western Canada. Although not yet collected in Newfound-

land, catkins of *A. rugosa* are regularly attacked by the powdery mildew *Erysiphe aggregata* (Peck) Farl. in eastern Canada. It appears as a white wooly growth between the scales.

ERYSIPHALES

In the powdery mildews, both the anamorph and teleomorph states are present, the latter usually appearing near the end of the growing season. Asci are formed in closed spherical bodies bearing variously shaped appendages and appear superficially on leaves and stems of herbaceous and arborial plants.

**Erysiphe cichoracearum* DC. ex. Mérat on *Aster puniceus* L., Berry Pond Trail, 17 September 1983, DAOM 193630 [teleomorph]; Mackenzie Mill Brook, East Arm of Bonne Bay, 23 July 1983, DAOM 193629 [anamorph only]. Numerous species of Asteraceae are infected by this mildew (Parmelee 1977).

Erysiphe polygoni DC. ex St. Amans on *Ranunculus acris* L. Mackenzie Mill Brook, east Arm of Bonne Bay, 23 July 1983, DAOM 193631; Green Garden, 1 Aug. 1983, DAOM 193632. Ascospores are normally more than two in each ascus whereas in *E. cichoracearum* they are normally two.

Phyllactinia guttata (Wallr.:Fr.) Lév. on *Alnus rugosa* (Du Roi) Spreng. Stag Brook Trail, 24 Sept. 1983, DAOM 193633. Also collected at Goose Bay, Labrador, October 1948, DAOM 184462, 184463. The lenticular ascocarps are visible on the underside of leaves without magnification. In eastern Canada, catkins are also regularly infected by *Erysiphe aggregata* (Peck) Farl. and *Taphrina robinsoniana*.

PYRENOMYCETES

The perithecia which enclose the asci are provided with a preformed pore, beak or neck. This teleomorph may form and mature on living tissue, or on dead tissue as a saprophyte, having increased its presence during the growing season as a parasitic anamorph or in the conidial state.

Apiosporina collinsii (Schw.) Höhn. on *Amelanchier bartramiana* (Tausch) Roem., road from visitor centre to Norris Point, 27 July 1983, DAOM 193621. The perithecia appear on the surface of a conspicuous black growth (subiculum) over the entire undersurface of the leaves. Slight witches'-brooming may be in evidence. This is a widespread parasite in Canada on *Amelanchier* spp.

Atopospora betulina (Fr.) Petrak (tar spot) on *Betula ? nana* L., summit of Gros Morne Mtn., 18

Sept. 1983. The shiny, slightly raised groups of perithecia are visible on both leaf surfaces but mainly on the upper surface. It was collected on *B. papyrifera* Marsh in Labrador, 48° 53'N, 89° 55'W, 9 Sept. 1961, DAOM 184577. Although the ascocarps are conspicuous on leaves in the growing season, they do not mature until the following spring. This species occurs across Canada on the above and other species of *Betula*. See also *Fungi Canadenses* [National Mycological Herbarium, Biosystematics Research Centre, Research Branch, Agriculture Canada, Ottawa] No. 88. One of the earliest collections in DAOM dates from 1813 (Mougeot and Nestler, *Stirpes Cryptogamae* Fasc. IV No. 370, Vosges-Rhine region, France).

Claviceps purpurea (Fr.) Tul. on *Calamagrostis inexpansa* A. Gray, Trout River Pond, 24 Aug. 1973, DAOM 193623; on *Deschampsia flexuosa* (L.) Trin., Port au Choix on Hy. 430 N of Park, 8 Sept. 1951, DAOM 38637. Records from Newfoundland are few but numerous elsewhere across Canada from southern Ontario to the Yukon and Northwest Territories. The grass hosts are numerous and in Canada include species in the genera *Ammophila*, *Agropyron*, *Bromus*, *Calamagrostis*, *Dactylis*, *Elymus*, *Festuca*, *Glyceria*, *Hierochloa*, *Hordeum*, *Lolium*, *Oryzopsis*, *Phalaris*, *Phleum*, *Poa*, *Secale*, *Spartina*, *Stipa* and *Triticum*.

**Glomerella cingulata* (Stonem.) Spauld. & Schrenk. on *Sarracenia purpurea* L., Trail to Bakers Brook, 31 July 1983, DAOM 193624. The pale brown circular leaf spots are conspicuous by the broad purple borders.

Mycosphaerella colorata (Peck) Earle on *Kalmia angustifolia* L., Berry Head Pond, 19 July 1983, DAOM 193625. Also known from Bader, 5 Aug. 1953 DAOM 40179 and Port-aux-Basques, 5 Aug. 1963, DAOM 115096. Leaf spots are small, circular with dark borders and with 1-3 perithecia in the pale centres of the upper surface. In DAOM, there are a number of specimens from Kouchibouguac National Park, New Brunswick, and the distribution ranges through Quebec to northern Ontario.

Mycosphaerella ribis (Fuckel) Felg. (anamorph: *Septoria ribis* Desm.) on *Ribes glandulosum* Grauer, talus south side Gros Morne Mtn., 20 July 1983, DAOM 193628; *Ribes lacustre* (Pers.) Poir, Berry Hill, 31 July 1983, DAOM 193626. This fungus attacks other species of *Ribes* in Canada (DAOM) but there are no specimens of it on *R. triste* Pall., the only other species recorded from the Park by Bouchard and Hay (1976). All of the specimens in DAOM were collected between June

and October and all bear the anamorph; it therefore appears that the fungus requires overwintering before the teleomorph matures.

Sphaerulina taxicola (Peck) Berl. on *Taxus canadensis* Marsh., Lomond, 7 July 1953, DAOM 40249. The perithecia appear over the upper surface of obviously overwintered needles and they bear mature ascospores. Ascocarps are in the same condition of maturity on another specimen from St. Leonard, New Brunswick, collected on 3 July 1957; however, asci are immature in an obviously parasitic needle infection of *Taxus brevifolia* Nutt. from Lumby, British Columbia, collected on 25 September 1972.

INOPERULATE DISCOMYCETES

The ascocarps open naturally by preformed slits or by various modifications of slits. As in the pyrenomycetes, the teleomorph may not mature until the following spring season but the anamorph (conidial state) is abundantly present during the growing season.

Diplocarpon earliana (Ell. & Ev.) Wolf (anamorph: *Marssonnia fragariae* (L.Fib.) Kleb.) on *Fragaria virginiana* Duchesne, Neddy Hill, Norris Point, 27 July 1983, DAOM 193637. Also on *F. chiloensis* Duchesne Mt. Pearl south of St. John's, 26 July 1949, DAOM 40543. The shiny black acervli are on the upper surface of leaf spots conspicuous by surrounding purple discolouration.

Diplocarpon maculata (Atk.) Jørst. (anamorph: *Entomosporium maculatum* Lév.) on *Sorbus americana* Marsh. talus of Gros Morne Mtn., 20 July 1983, DAOM 193638 and 193641; Information Centre S of Rocky Harbour, 30 July 1983, DAOM 193640. The conidia fruit on the upper surface of small necrotic leaf spots which are usually quite numerous. This Canada-wide species attacks other hosts in the Rosaceae (Pomoideae: *Amelanchier*, *Crataegus*, *Cydonia*, *Pyrus*).

Drepanopeziza ribis (Kleb.) Höhn. (anamorph: *Gloeosporium ribis* (Lib.) Mont.) on *Ribes glandulosum* Grauer, Berry Hill Campground 17 July 1903, DAOM 193642; Berry Head Pond, 19 July 1983, DAOM 193643; on *Ribes lacustre* (Pers.) Poir., Berry Hill Campground, 31 July 1983, DAOM 193652. In Canada many species of *Ribes* are susceptible to anthracnose including the cultivated *R. alpinum* L., *R. nigrum* L., *R. sativum* Syme. Connors (1967) records this leaf spot on *R. nigrum* from Newfoundland.

**Leptotrochila ranunculi* (Fr.) Schüepp. on *Ranunculus acris* L., Mackenzie Mill Brook, East Arm of Bonne Bay, 23 July 1903, DAOM 193656. Connors (1967) drew attention to the similar

Pseudopeziza singularis (Peck) Davis and the differences (blue staining, positive reaction of ascus annulus of *L. ranunculi* and the negative result for *P. singularis*) are documented and illustrated in Fungi Canadenses No. 228 and 229.

Lirula nervata (Darker) Darker (= *Hypodermella n.* Darker) on *Abies balsamea* L., Lomond, 7 July 1953, DAOM 40246. Also from Lake St. John, 26 June 1953, DAOM 40248. A full description of this needle cast fungus and others on conifers is provided by Darker (1932, 1967). Records in DAOM are only from eastern Canada.

Lophodermium arundinaceum (Schrad.) Chev. on *Elymus mollis* Trin., the Arches just N of Park Boundary, 2 Aug. 1983, DAOM 193653. Also in DAOM, there are Canada-wide collections that range well into the Arctic (Franklin Dist. and Ellesmere Island) on this and other grass genera such as *Festuca*, *Phippsia* and *Puccinellia*.

Lophodermium exaridum (Cke. & Peck) Sacc. on *Kalmia angustifolia* L., trail to Bakers Brook from Berry Hill, 31 July 1983, DAOM 193654. *Kalmia* is an evergreen shrub and mature ascocarps may be found on year old leaves.

Placuntium andromedae (Pers. ex Fr.) Höhn. (= *Rhytisma a.* (pers.) Fr.) on *Andromeda glaucophylla* Link, Green Point, 26 June 1972, DAOM 193655. Elsewhere in Newfoundland at Whitbourne, Avalon Pen., 26 Aug. 1984, DAOM 24387; St. Anthony, 5 July 1951, DAOM 53102(b); 5 mi N of Port-aux-Basques, 5 Aug. 1963, DAOM 115118 ex TRTC 40754. On this host the fungus occurs only in eastern Canada; in western Canada it is known (DAOM) only on *A. polifolia* L.

Rhytisma prini (Schw.) Fr. (= *R. ilicis-canadensis* Schw.) on *Nemopanthus mucronata* (L.) Trel., Berry Hill Campground, 17 July 1983 DAOM 193657(b), 193664; trail to Southeast Brook Falls, 23 July 1983, DAOM 193658; trail to Western Brook Pond, 22 July 1983, DAOM 193660; Park Information Centre, 30 July 1983, DAOM 193662; trail to Bakers Brook, 31 July 1983, DAOM 193661; Stag River, 14 Aug. 1972, DAOM 193663; Trout River Pond, 24 Aug. 1972, DAOM 193659. The black ascocarps (tar spots) are conspicuous on both leaf surfaces and surrounding leaf tissue is chlorotic. *Rhytisma* is found also on *Ilex verticillata* (L.) Gray in eastern Canada. The two hosts are in the family Aquifoliaceae and it is likely that the one species attacks both. However tar spot is not known in *Ilex* in Newfoundland at this time.

Rhytisma punctatum (Pers.) Fr. on *Acer rubrum* L., trail to Bakers Brook from Berry Hill, 31 July 1983, DAOM 193665. Characterized by

very small tar spots in circular groups on the upper surface of leaves. The fungus is common in Canada, attacking many species of maple and it is known to occur widely in eastern Canada on *Acer spicatum* Lam., the only other maple found in Newfoundland. The specimen cited bears also *Phleospora aceris* (Lib.) Sacc.

Rhytisma salicinum (Pers.) Fr. on *Salix* sp., Table Mtn. SW of Woody Point, 28 July 1983, DAOM 193666. Known also in Labrador, Aug. 1896, DAOM 194838. This is a very common parasite on many species of willow and it is found from coast to coast in Canada into the high arctic. The ascocarps must overwinter before mature asci are produced. Numerous sites where willow and maple tar spots have been collected in Newfoundland are given by Singh and Carew (1973).

**Valdensinia heterodoxa* Peyr. on *Vaccinium ovalifolium* J. E. Sm., E side Gros Morne Mtn. alt. ca. 1750 ft. (534 m), 18 Sept. 1983, DAOM 193670. Other blueberries in eastern Canada attacked by this leaf-spotting fungus include *V. angustifolium* Ait. and *V. myrtilloides* Michx. In western Canada, *Gaultheria shallon* Pursh is a known host (Redhead and Perrin 1972) sub *Asterobolus*.

UREDINALES

The rust fungi are obligate parasites of vascular plants and may have up to five spore states in their complete life cycle. The cycle is completed on a single host (autoecious) or on two unrelated hosts (heteroecious) and infection may be localized, systemic, annual or perennial. Anamorphs of these fungi include the pycnial (0), aecial (I), and uredinal (II) states, while the teleomorphs include only the telial state (III).

Chrysomyxa empetri Schröt. ex Cumm. 0,I on needles of *Picea glauca* (Moench) Voss, Lobster Cove Head, 16 July 1983, DAOM 193229; Neddy Hill at Norris Point, 27 July 1983, DAOM 193228; other sites in Newfoundland represented in DAOM: St. Anthony, Englee, Carboneau, Hearts Content, Hearts Delight, New Pillican, Seal Cove, Topsail, Victoria, and Whitebourne (all but the first two on the Avalon Peninsula). II,III on the abaxial surfaces of the leaves of *Empetrum nigrum* L., Neddy Hill at Norris Point, 27 July 1983, DAOM 193236 contiguous with 193228; other sites in Newfoundland with strong associations with aecia on *Picea*: Englee, St. Anthony; also Mealy Mts. in Labrador, 11–15 July 1950, DAOM 33967.

Chrysomyxa ledi (Alb. & Schw.) deBary vars. 0,I on needles of *Picea mariana* (Mill.) BSP., not collected in the Park in 1983; Glenwood Hy. I, W of

Gander, 11 Aug. 1953, DAOM 40204; Terra Nova Hy. I, SE of Gander, 14 Aug. 1954, DAOM 46106. var. *groenlandici* Savile II,III on undersurface of leaves of *Ledum groenlandicum* Oeder, not collected in the Park in 1983; elsewhere at St. Anthony, July 1951, DAOM 45413, 45440, 45442. var. *rhododendri* (de Bary) Savile II,III on underside of leaves of *Rhododendron lapponicum* (L.) Wahl., not collected in the Park; elsewhere at St. Anthony, 29 June 1951, DAOM 45485.

Chrysomyxa ledicola Lagerh. 0,I on needles of *Picea glauca* (Moench) Voss, Lobster Cove Head, 21 July 1983, DAOM 193230; trail to Green Garden, 24 July 1983, DAOM 193231; Rocky Harbour, 17 July 1983, DAOM 193232; on *Picea mariana* (Mill.) BSP., Berry Hill Campground, 17 July 1983, DAOM 193234; Berry Head Pond, 19 July 1983, DAOM 193241; below Gros Morne Mtn., 20 July 1983, DAOM 193240; trail to Western Brook Pond, 22 July 1983, DAOM 193242. II,(III) on the upper leaf surfaces of *Ledum groenlandicum* Oeder, (Labrador tea) Berry Hill Campground, 17 July 1983, DAOM 193239; Berry Head Pond, 19 July 1983, DAOM 193233; below Gros Morne Mtn., 20 July 1983, DAOM 193233; below Gros Morne Mtn., 20 July 1983 DAOM 193238.

All spore states were collected at St. Anthony in 1951 on all known hosts (10 specimens in DAOM) and rust on either aecial or telial hosts is known (8 specimens, DAOM) from Port-aux-Basques, Stephenville, Grand Falls, St. John's and other sites on the Avalon Peninsula. In Labrador, rust on *Ledum* is known from Goose Bay and the Mealy Mountains. In 1983, the knee-high spruce below Gros Morne Mountain and along the trail to Western Brook Pond appeared yellow *en masse* from the presence of aecia on current year needles. At both sites the alternate host, Labrador Tea, was common.

Chrysomyxa pirolata Wint. 0,I systemic on cone scales of *Picea glauca* (Moench) Voss, not collected in the Park, no specimens in DAOM from Newfoundland. It has been known in the Atlantic Provinces at least since 1910 (DAOM). II,III perennial and systemic on undersurfaces of leaves of *Moneses uniflora* (L.) Gray, Berry Head Pond, 19 July 1983, DAOM 193235; known also in Labrador: Goose Bay, 6 July 1950, DAOM 26547 and Carol Lake (ca. 53°N 67°W), 1953, DAOM 55030; on *Pyrola minor* L., Neddy Hill At Norris Point, 27 July 1983, DAOM 193257. The life history and spore morphology of the rust was investigated recently by Sutherland et al. (1984).

Chrysomyxa woronini Tranz. 0,I stunting the young needles (shoots) of *Picea mariana* (Mill.)

BSP., not collected in the Park but found regularly at St. Anthony in 1951: DAOM 45379, 45488, 45499, 45505. III on the undersurface of systemically infected, current season leaves of *Ledum groenlandicum* Oeder. Six specimens from St. Anthony collected in 1951, DAOM 45487 in association with rusted *Picea* DAOM 45488 above. *Picea glauca* (Moench) Voss and *Ledum palustre* L. var. *decumbens* Ait. may also bear this rust.

Coleosporium asterum (Diet.) Syd. 0,I causes a localized needle rust of *Pinus resinosa* Ait. in Newfoundland (Singh and Carew 1973) but it was not found in the Park in 1983. II,(III) on undersurfaces of leaves of *Aster* ? *puniceus* L., trail to Green Garden, 1 Aug. 1983, DAOM 193260. Also on *Solidago macrophylla* Pursh, St. Anthony, 26 Aug. 1951, DAOM 182300; on *S. uliginosa* Nutt., St. Anthony, 23 July 1951, DAOM 182299; on *Solidago* sp., nr. Bishops Falls, 5 Aug. 1953, DAOM 40173. Red Pine has a restricted distribution in Newfoundland (Hosie 1979) and it is noteworthy that the telial hosts (Asteraceae) at St. Anthony, some 150 miles from hard pines, become infected. All hard pines are susceptible to this rust whose distribution is Canada-wide. This and other tree rusts are illustrated by Ziller (1974).

Coleosporium campanulae (Pers.) Lév. 0,I on needles of *Pinus* spp. but not known to occur in Canada; II,III on abaxial leaf surfaces of *Campanula rotundifolia* L., Neddy Hill at Norris Point, 21 July, 1983, DAOM 193261; Serpentine Mountains, 4 km W of Woody Point, 24 July 1983, DAOM 193258 and 10 Aug. 1978, DAOM 169298. Also at Port au Choix, 8 Sept. 1951, DAOM 178501(a). In the absence of known pine infections, it is expected that uredinia carry the rust overwinter, maintaining it independent of host alternation. See Fungi Canadensis No. 218.

Cronartium ribicola J.C. Fischer 0,I on stems and branches of *Pinus strobus* L. causing perennial cankers on which aecia appear as white blisters full of orange masses of aeciospores. Not found in the Park in 1983 nor was the host recorded by Bouchard and Hay (1976). However, this rust is widely scattered across central Newfoundland, indeed, near the southern boundary of the Park, according to Singh and Carew (1973). II,III on undersurface of leaves of *Ribes* spp. — the telia as slender pillar-like chains of spores. On *Ribes glandulosum* Grauer, nr. Gander Airport, 9 Aug. 1941, DAOM 195158.

Gymnoconia peckiana (Howe) Trotter 0,I(III) systemic on leaves of *Rubus pubescens* Raf., not collected in the Park in 1983 although this host and other susceptible species (*R. acaulis* Michx. and *R.*

idaeus L.) are recorded there by Bouchard and Hay (1976). Known from St. Anthony, 23 June 1951, DAOM 40908 and 6 July 1951, DAOM 40907; also from Goose Bay, Labrador, 10 June 1950, DAOM 27394.

Gymnosporangium clavariiforme (Jacq.) DC. 0,I localized infection on leaves and fruits of *Amelanchier bartramiana* (Tausch) Roem., SE slope Gros Morne Mtn., 20 July 1983, DAOM 193246; Southeast Brook, East Arm Bonne Bay, 23 July 1983, DAOM 193248; trail to Green Garden, 24 July 1983, DAOM 193251; Berry Hill, 31 July 1972, DAOM 193249; *A. laevis* Wieg., talus, south side Gros Morne Mtn., 20 July 1983, DAOM 193256; *A. spicata* (Lam.) K. Koch, 20 July 1983, talus south side Gros Morne Mtn., DAOM 193262. Also general around St. Anthony in August 1951, DAOM 91942, 91962, 91973; III cylindrical telial horns on branches of *Juniperus communis* L. var. *depressa* Pursh, not collected in the Park in 1983, as telia mature in May–June prior to the 1983 field collecting. Mature telia were collected near St. Anthony, 3 June 1951, DAOM 91925. See Fungi Canadensis No. 115.

Gymnosporangium clavipes (Cke. & Peck) Cke. & Peck 0,I localized on leaves, fruits and young twigs of *Amelanchier bartramiana* (Tausch) Roem., talus south side Gros Morne Mtn., 20 July 1983, DAOM 193252; southeast side Gros Morne Mtn., 20 July 1983, DAOM 193245; trail to Green Garden 24 July 1983, DAOM 193244; also known at St. Anthony, 18 August 1951, DAOM 91963. Elsewhere in Canada other species of *Amelanchier* become rusted along with *Aronia*, *Cotoneaster*, *Crataegus*, *Cydonia*, *Malus* and *Sorbus*. See Fungi Canadenses No. 116. III orange, cushion-shaped telia form on the adaxial side of needles and on young twigs of *Juniperus communis* L. var. *depressa* Pursh. As in the previous species not collected in the Park but will doubtless be found if sought in May–June.

Gymnosporangium cornutum Arth. & Kern. 0,I localized on leaflets of *Sorbus americana* Marsh, Berry Hill Campground, 17 July 1983, DAOM 193250; talus south side Gros Morne Mtn., 20 July 1983, DAOM 193638 (mixed with leaf spot *Diplocarpon maculatum*); trail to Green Garden, 24 July 1983, DAOM 193247; *S. decora* (Sarg.) Schneid., 27 July 1983, Neddy Hill at Norris Point, 27 July 1983, DAOM 193253; Lomond, 20 July 1953, DAOM 40251; all specimens cited above are immature. Aecia do not normally mature until late August–September. Also on *S. decora* (Sarg.) Schneid., Bona Vista, St. Anthony, 1, 3 September 1951, DAOM 92047, 92048. III on dark brown

cushion-shaped telia on the adaxial side of needles of *Juniperus communis* L. var. *depressa* Pursh, not collected in the Park in 1983 but surely present based on the heavy infections encountered on the Mountain-ash. See Fungi Canadenses No. 117.

**Gymnosporangium nidus-avis* Thaxt. 0,I localized on undersurface of leaves of *Amelanchier* spp. Aecia were not collected in the Park in 1983; III forms orange, cushion-shaped telia on or between the imbricated needles of dense witches' brooms on *Juniperus horizontalis* Moench, trail to Green Garden, 24 July 1983, DAOM 193243, specimen overmature. In Ontario this rust invades *J. virginiana* L. and *J. scopulorum* Sarg. in British Columbia. See Fungi Canadenses No. 139.

**Hyalopsora aspidiotus* (Magn.) Magn. 0,I undersurface of needles of *Abies balsamea* L., Southeast Brook, East Arm Bonne Bay, 23 July 1983, DAOM 193372; II(III) on discrete intercostal necrotic areas on both sides of fronds of *Gymnocarpium dryopteris* (L.) Newm., Southeast Brook associated with 193372, 23 July 1983, DAOM 193264. This is a widely distributed species in Canada with specimens (DAOM) from all provinces except Manitoba and Saskatchewan.

Melampsora epitea Thüm. 0,I on needles of *Abies balsamea* (L.) Mill. not collected in the Park in 1983; II,III powdery bright yellow uredinal pustules and darker, leathery telial pustules on the undersides of leaves of *Salix ?arctophila* Cockerell, Serpentine Mts. 4 km W of Woody Point, 24 July 1983, DAOM 193265; *S. ? planifolia* Pursh, small pond north side Bonne Bay, 24 July 1983, DAOM 193266. This is a complex species, formerly treated as a number of separate species by Arthur (1934), and as such it has world-wide distribution.

Melampsorella caryophyllacearum Schröt. 0,I perennial and systemic in elongated witches' brooms whose needles are yellowed and malformed; on *Abies balsamea* (L.) Mill., Green Point, 22 July 1983, DAOM 193267; Shallow Bay Campsite, 25 July 1983, DAOM 193268; The Arches N of Park boundary, 2 Aug. 1983, DAOM 193269; also Whiteway Trinity Bay, 28 July 1949, DAOM 39885; II,III usually systemic on leaves and shoots of *Stellaria media* (L.) Cyrillo, not found in the Park in 1983 but elsewhere in the province near Bigus, Conception Bay, 27 July 1949, DAOM 23507 and near Tompkins, Codroy Valley, 14 Aug. 1949, DAOM 23508. Rust is widely distributed in Canada, even into the Arctic on the telial hosts above tree line (Parmelee 1984), involving other host species of *Abies*, *Stellaria* and *Cerastium*.

Nyssopsora clavellosa (Berk.) Arth. III black, eventually powdery pustules on the upper surfaces

of leaves of *Aralia nudicaulis* L., Western Brook Pond, 22 July 1983, DAOM 193286; trail to Bakers Brook, 31 July 1983, DAOM 193289; Western Brook Trail, 24 Sept. 1983, DAOM 193287. For illustration and distribution in Canada see Fungi Canadenses No. 221.

**Phragmidium andersonii* Shear 0,I,II,III on *Potentilla fruticosa* L., trail to Green Garden, 1 Aug. 1983, DAOM 193290; trail to Bakers Brook from Berry Hill, 23 July 1983, DAOM 193285; Lomond, 7 Aug. 1953, DAOM 40181. All spore states cause localized leaf infections. The multicelled teliospores are large enough to be seen without magnification and have hygroscopic pedicels. *Phragmidium* species are parasitic on the tribes Potentilleae, Roseae and Rubeae of the Rosaceae. A number of Canadian species not included herein are treated in the first century of Fungi Canadenses Nos. 41, 54, 79, 80.

Phragmidium rubi-idaei (DC.) Karst. 0,I,II,III with pustules mainly on the lower surfaces of leaves made conspicuous by chlorosis of the infected tissue, on *Rubus idaeus* L. var. *strigosus* (Michx.) Maxim., trail to Green Garden, 1 Aug. 1983, DAOM 193293. Also a collection by the Rev. A. C. Waghorne collected at "Chimney Cove" [There are at least six such place names in Newfoundland] 12 September 1892. Commonly called 'yellow rust', it should not be confused with 'late yellow rust' (*Pucciniastrum americanum* (Farl.) Arth.) which also attacks the cultivated raspberry but which is markedly different in spore appearance and in its heteroecious life cycle involving *Picea glauca*.

**Puccinia albulensis* Magn. ssp. *albulensis* III usually systemic but sometimes localized on *Veronica alpina* L., near Crater Lake, North Hebron Valley, Labrador, 30 July 1954, DAOM 45538. This specimen was recorded by Savile (1968) in his treatment of *Puccinia* on Scrophulariaceae. The host is arctic-alpine and many of the specimens cited in that work are from the North American Cordillera.

Puccinia angustata Peck II, III on *Eriophorum angustifolium* Honckeny, localized on leaves, near Stephenville, 14 June 1949, DAOM 23550; also known on *Scirpus* spp. Teliospores germinate to produce basidiospores which infect the alternate hosts *Lycopus* spp. and *Mentha* spp. Rust is widely distributed elsewhere in eastern Canada.

**Puccinia bistortae* (Str.) DC. 0,I on *Conioselinum chinense* (L.) BSP. as localized infections on leaves and stems at St. Anthony in July 1951 and in association with rusted *Polygonum*: DAOM 54557, 54563-4-5 and 54610;

on *Ligusticum scoticum* L., same year and location DAOM 54569; II,III localized on undersurfaces of leaves of *Polygonum viviparum* L., Cow Head lighthouse, 25 July 1983, DAOM 193294; also late July at St. Anthony associated with *Conioselinum* above, six specimens DAOM 54566-7-9 and 54558, 54609, 54611; also nr. Crater Lake W of Hebron, Labrador, 1 Aug. 1954, DAOM 45567. Distribution ranges into the Canadian Arctic where it exists on *Polygonum* without host alternation. Label notes on DAOM 54566 indicate that uredinia apparently overwintered, as there were no aecia nearby. Another rust, *Puccinia septentrionalis* Juel with uredinia and telia on *Polygonum viviparum* alternates (0,I) to *Thalictrum* (Ranunculaceae) instead of Apiaceae. It was reported from Newfoundland (Arthur 1934) without collection data but was attributed to Waghorne, thus placing the date of collection in the late 1800s. Urediniospore and teliospore characters are separable from those of *P. bistortae*.

Puccinia campanulae Carm. ex Berk. III localized on stems, petioles and lower surfaces of leaves on *Campanula rotundifolia* L., Port au Choix, 8 Sept. 1951, DAOM 178501(b), rusted also with *Coleosporium campanulae* (Pers.) Lév. See Fungi Canadenses No. 219.

****Puccinia calthae*** Link 0,I,II,III localized and mainly on the undersurfaces of leaves of *Caltha palustris* L., Western Brook Pond, 22 July 1983, DAOM 193326; Berry Hill Campground, 17 July 1983, DAOM 193325. In Fungi Canadenses No. 270, the Canadian distribution is listed only as Ontario and Manitoba but it also ranges southward into the United States. Teliospore characters permit separation from *P. calthicola*.

****Puccinia calthicola*** Schröt. 0,I,II,III localized on either surface of leaves of *Caltha palustris* L., road to Norris Point, 27 July 1983, DAOM 193327; Callaghan Trail, 29 July 1983, DAOM 193328. Distribution in Canada is somewhat broader than for *P. calthae* as it includes Saskatchewan and Manitoba to the west and Quebec to the east — see Fungi Canadenses No. 271. The two rusts on *Caltha* can be recognized on spore characters: teliospores are shallowly verrucose vs. smooth in *P. calthae* and aeciospores bear pore plugs vs. plugs absent.

Puccinia caricina DC. (= *P. pringsheimiana* Kleb.) 0,I localized on leaves of *Ribes* spp. not found in the Park in 1983, but (ex DAO) on *Ribes glandulosum* Grauer, Holyroad, 22 June 1957, DAOM 195157; and on *R. hirtellum* Michx., Humbermouth, 5 July 1950; DAOM 195156. II,III localized on leaves of *Carex brunnescens* (Pursh)

Poir., talus south side Gros Morne Mtn., 20 July 1983, DAOM 193329; *C. canescens* L. southeast side Gros Morne Mtn., 20 July 1983, DAOM 193330; trail to Bakers Brook, 31 July 1983, DAOM 193331; *C. paupercula* Michx., Cow Head, 3 Aug. 1983, DAOM 193332; also St. Anthony, 26 Aug. 1951, DAOM 177450; *Carex* sp. Birchy Narrows, Sandy Lake Hy. No. 1, 27 Sept. 1983, DAOM 193333. This is a complex of species-varieties occurring from coast to coast in Canada with a world-wide distribution.

****Puccinia centaureae*** DC. 0,I,II,III localized uredinia on both leaf surfaces of *Centaurea nigra* L. near Glenburnie, 24 July 1983, DAOM 193319. This rust occurs rarely in Canada; it is known from a single collection from near Lunenburg, Nova Scotia (DAOM 110303) and another from Victoria, British Columbia (DAOM 193536). It is of European origin as indicated by Savile (1970).

Puccinia circaeae Pers. III mainly on the undersurface and surrounded by conspicuous, chlorotic leaf tissue of *Circaea alpina* L., trail to Bakers Brook from Berry Hill, 31 July 1983, DAOM 193321; trail to Green Garden, 1 Aug. 1983, DAOM 193320; also from Salmonier River, Avalon Pen. 26 Aug. 1894, DAOM 24368 and from Goose Bay, Labrador July–Aug. 1950, DAOM 25389 and 25390. Other species of *Circaea* elsewhere in Canada also bear this rust.

Puccinia cnici Mart. 0,I,II,III on *Cirsium vulgare* (L.) Scop. near Eastport, Bonavista Bay, 2 Aug. 1949, DAOM 23651. All localized infections. The aecia are caecoid, not cupulate as is typical in *Puccinia*. Known only from this single collection in Newfoundland but this rust occurs from coast to coast in Canada (Savile 1970).

****Puccinia columbiensis*** Ell. & Ev. III in compact, circular groups on both surfaces of leaves of *Prenanthes trifoliata* (Cass.) Fern., southeast slope of Gros Morne Mtn., 20 July 1983, DAOM 193323; Serpentine tableland SW of Woody point, 21 July 1983, DAOM 193322. Other hosts in the Asteraceae: Cichorieae, including *Agoseris*, *Hieracium* and *Krigia*. The smooth teliospore wall of *Puccinia columbiensis* is an easily used character for distinguishing *P. orbicula* Peck & Clint., with verrucose teliospore walls, on the same host.

Puccinia coronata Cda. 0,I localized on leaves of *Shepherdia canadensis* (L.) Nutt., Green Garden, 1 Aug. 1983, DAOM 193301; *Rhamnus alnifolia* L'Hér., Lomond, 5 July 1953, DAOM 40236; Pinchgut, 1 July 1953, DAOM 40237. II,III localized on leaves of many genera of Poaceae: *Calamagrostis canadensis* (Michx.) Nutt., trail to

Western Brook Pond, 22 July 1983, DAOM 193303; *Elymus mollis* Trin., the Arches N of the Park boundary, 2 Aug. 1983, DAOM 193324. Among other grasses listed for the Park by Bouchard & Hay (1976) and susceptible to *P. coronata* are species of *Agropyron*, *Agrostis*, *Ammophila*, *Bromus*, *Glyceria*, *Hordeum* and *Poa*.

**Puccinia dioicae* P. Magn. 0,I in small circular groups on the undersurface of leaves of *Solidago macrophylla* Pursh, Gros Morne Mtn., 20 July 1983, DAOM 193302 and 193306. Among the genera of Asteraceae which are known to become rusted elsewhere in Canada are *Agoseris*, *Erigeron*, *Hieracium*, *Lactuca* and *Senecio*. II,III localized on leaves of *Carex bigelowii* Torr., Western Brook Pond, 6 July 1972, DAOM 193304; *Carex recta* Boott, Martin Point, 7 July 1972, DAOM 193305. Also on *C. abdita* Bickn., Goose Bay, Labrador, 16 June 1950, DAOM 25148 and 16 Aug. 1950, DAOM 25149; *C. argyrantha* Tuckerm., Goose Bay Labrador, 22 July 1950, DAOM 25389 and 23 Aug. 1950, DAOM 25390. This species differs from *P. caricina*, also on *Carex*, in having larger urediniospores and teliospores and in having the aecial hosts in Asteraceae rather than in the Urticaceae or the Saxifragaceae. However, like *P. caricina* it has been treated here as a species complex and some of its elements have been recognized as separate species or as varieties by others.

**Puccinia hieracii* (Röhl) Mart. 0,II¹,II²,III localized on both surfaces of leaves of Cichorieae: *Hieracium canadense* Michx., near Glenburnie, 24 July 1983, DAOM 193310; top of Table Mtn., 28 July 1983, DAOM 193308; Barachois Brook, East Arm of Bonne Bay, 30 July 1983, DAOM 193312; also Pasadena SW of Deer Lake, 15 Aug. 1949, DAOM 40540; E. of Tompkins N of Port-aux-Basques, 16 Aug. 1949, DAOM 23650; *Leontodon autumnalis* L., Lobster Cove Head NW of Rocky Harbour, 16 July 1983, DAOM 193314; Norris Point, 21 July 1983, DAOM 193315; Cow Head lighthouse, 25 July 1983, DAOM 193313; Norris Point, 27 July 1983, DAOM 193309; also Gander, 20 June 1949, DAOM 23537 and St. Anthony, 7 Aug. 1951, DAOM 55706; *Taraxacum officinale* Weber, Cove Head, 16 July 1983, DAOM 193307; Norris Point, 21 July 1983, DAOM 193311; also Stephenville, St. Georges Bay, 23 May 1949, DAOM 23578, and near St. Anthony, 14 Aug. 1951, DAOM 55708. The distribution of this species is nearly world wide; it occurs in all provinces of Canada and into the Northwest Territories. See Parmelee and Savile (1981) for description and illustration.

Puccinia linkii Klotzsch, III as localized infections on *Viburnum edule* (Michx.) Raf., Tompkins, Codroy Valley, 16 Aug. 1949 DAOM 23547. The dark brown telia are conspicuous mainly on the upper surface of leaves but sometimes on lower surface vascular tissue and even on young twigs. Commonly found in eastern Canada extending westward through northern Ontario and Manitoba to the Slave Lake region of Alberta.

Puccinia mesomejalis Berk. & Curt. III orange-brown pustules in tight circular groups on both surfaces of leaves of *Clintonia borealis* (Ait.) Raf., Berry Hill Campground, 17 July 1983, DAOM 193318; SE slope Gros Morne Mtn., 20 July 1983, DAOM 193316; trail to Western Brook Pond, 22 July 1983, DAOM 193317; Southeast Brook, 23 July 1983, DAOM 193295; also SW of Gander, 24 June 1949, DAOM 23584; St. Anthony, 5-8-16 July 1983, DAOM 83135, 83133, 83134, respectively, and two old collections, one by Robinson and Schrenk from Virginia Water, 8/5/94, DAOM 24369 Ex Herb. Harvard Univ., and the other by Waghorne from East River, date not decipherable (presumably 1890s). This rust is common from Ontario eastward, in Alberta and British Columbia the host is *C. uniflora* (Schult.) Kunth.

Puccinia orbicula Peck & Clint. 0,I,II,III or 0 II¹II²III or 0,III [a variable life cycle] usually on both surfaces of leaves of *Prenanthes trifoliata* (Cass.) Fern., Rocky Harbour, 27 July 1983, DAOM 193296; also St. Anthony, 8 July 1951, DAOM 55214 and 30 July 1951, DAOM 55211; Englee, 2 Aug. 1951, DAOM 55667; near Eastport Bonavista Bay, 2 Aug. 1949, DAOM 23538; Grand Falls, 22 June 1953, DAOM 40232 and Lark Harbour, Bay of Islands, by Waghorne, "5/8/98" = Ell. & Ev., F. Col. 1381. In the provinces and states bordering the Pacific Ocean, *Prenanthes alata* (Hook.) D. Dietr. bears *Puccinia insperata* Jacks. whose spore differences from *P. orbicula* are listed by Parmelee and Savile (1981).

**Puccinia poae-nemoralis* Otth 0,I on *Berberis* in India (Cummins 1971) but unknown in North America; II,III on *Anthoxanthum odoratum* L., Berry Hill Campground, 17 July 1983, DAOM 193298; *Poa glauca* Vahl, St. Anthony, 16 July 1951, DAOM 144896; *P. palustris* L., S. of Rocky Harbour, 21 July 1983, DAOM 193297. This species is given varietal rank under *P. brachypodii* Otth by Cummins (1971). Many other grass genera bear this rust, many also bearing *P. poarum*.

**Puccinia poarum* Niels. 0,I causes conspicuous leaf spotting with pycnia on upper surface and

aecia on lower surface of *Tussilago farfara* L., Lobster Cove Head NW of Rocky Harbour, 16 July 1983, DAOM 193278 (overmature); S of Rocky Harbour, 21 July 1983, DAOM 193279 (much overmature); II,III localized infection on leaves of *Poa pratensis* L., Lobster Cove Head, NW of Rocky Harbour, associated with 193278, 21 July 1983, DAOM 193279. Paraphyses were not seen in the uredinia (cf. previous species) and telia had not yet formed. Cummins (1971) draws attention to similarity of this species to *P. recondita* whose aecia occur on entirely unrelated hosts (Ranunculaceae and others). There is also similarity to *P. poae-sudeticae* whose aecia on Berberidaceae are not known to occur in North America. Aecia of *P. poarum* occur on other genera of Asteraceae including *Liatris* in western Canada (Parmelee 1984).

Puccinia porphyrogenita Curt. III black, pulvinate, solitary telia scattered on undersurface of leaves of *Cornus canadensis* L., Lomond, 7 Aug. 1953, DAOM 40175; and 7 collections from Lobster Cove Head to Shallow Bay during 16–31 July 1983: DAOM 193272-3-4-5-6-7, 193280. Also from Goose Arm, 8 Aug. 1953, DAOM 40176; Bishop's Falls Ferry, 5 Aug. 1953, DAOM 40177 and from Bay of Islands, Oct. 1897 (Waghorne) in DAOM (no number). This rust occurs from coast to coast in Canada ranging northward to Fort Liard in the Mackenzie Valley. The rusted leaves of 193274 also bear *Glomopsis corni* (Peck) Henderson.

Puccinia punctata Link var. *punctata* 0,I,II,III localized on *Galium asprellum* Michx. near Tompkins, 20 Aug. 1949, DAOM 23546; South Branch, 9 Aug. 1963, DAOM 114995 (= TRTC 40815). In eastern Canada *Galium palustre* L. becomes rusted as do *G. labradoricum* Wieg. and *G. trifidum* L. in western Canada.

Puccinia punctiformis (Str.) Röhl. 0,II¹,II²,III on *Cirsium arvense* (L.) Scop. Primary infections appearing early in the growing season are systemic, later secondary infections are localized. Lomond, 4 Aug. 1949, DAOM 40536. This rust is restricted to *C. arvense* and occurs with it throughout Canada.

****Puccinia variabilis*** Grev. 0,I,II,III mainly amphigenous sori, localized on leaves of *Taraxacum officinale* Weber, Neddy Hill, Norris Point, 21 July 1983, DAOM 193281. This rust is known from scattered collections in eastern Canada (Parmelee and Savile 1981) and is not nearly as common as *Puccinia hieracii* also on *Taraxacum*. *P. variabilis* possesses all spore states, including cupulate aecia, urediniospores completely echinulate with 2–3 equatorial pores while

P. hieracii has primary uredinia and urediniospores with conspicuous bare areas below each of the two superequatorial pores. In the Key (Parmelee and Savile 1981: 1079), other morphologically similar rusts are evident.

Puccinia violae (Schum.) DC. ssp. *americana* Savile (0,I),II,III with all states localized on leaves of *Viola* ? *incognita* Brain., Green Garden, 1 Aug. 1983, DAOM 193270; *V. pallens* (Banks) Brain., Neddy Hill, Norris Point, 27 July 1983, DAOM 193271. Additional to the two host species above, among the *Viola* spp. listed for the Park (Bouchard and Hay 1976), *V. cucullata* Ait., *V. renifolia* Gray and *V. septentrionalis* Greene, become rusted elsewhere (Fungi Canadenses No. 75). This rust on *Viola* spp. is now known in all provinces in Canada and into the subarctic.

Pucciniastrum americanum (Farl.) Arth. 0,I on current year needles of *Picea glauca* (Moench) Voss but not seen in the Park in 1983 nor are specimens known elsewhere in the province; II,(III) causes yellow-brown leaf discolouration and with uredinia appearing on the undersurface of *Rubus idaeus* L. var. *strigosus* Michx., Mackenzie Brook, East Arm, Bonne Bay, 23 July 1983, DAOM 193255. Light rust occurred at St. John's in 1958 (Anonymous 1960a). Loss to fruit yield occurs when fruits become rusted. Known to occur throughout the Maritime Provinces where losses reported (Conners 1967).

Pucciniastrum arcticum Lagerh. 0,I on current year needles of *Picea glauca* (Moench) Voss but with doubtful differences from the previous species. Not collected in 1983. II,III on yellowed leaf discolourations of *Rubus pubescens* Raf., Berry Hill, 31 July 1983, DAOM 193407; trail to Green Garden, 1 Aug. 1983, DAOM 193408. The two rusts on *Rubus* can be distinguished by uredinal characters. In *P. americanum* peridial cells have protruding, knobbed and echinulate tips, whereas in *P. arcticum* they are not knobbed. In July 1951 a number of collections were taken on *R. pubescens* from St. Anthony: DAOM 40886-7-8-9.

Pucciniastrum epilobii Otth 0,I on current year needles of *Abies balsamea* (L.) Mill., numerous sites recorded by Singh and Carew (1973) but there are no records from the Park. II,III on the undersurface of leaves of *Epilobium angustifolium* L., not found in the Park in 1983 but known from Bishops Road, 5 Aug. 1953, DAOM 40175; near St. Anthony, 11 Aug. 1951, DAOM 40878 and Terrington Basin, Goose Bay, Labrador, 16 Aug. 1950, DAOM 40852. See also *Pucciniastrum pustulatum*.

Pucciniastrum goeppertianum (Köhn.) Kleb. 0,I white, cylindric acelia on the abaxial surface of current year needles of *Abies balsamea* (L.) Mill., Shallow Bay Campsite, 25 July 1983, DAOM 193401; Neddy Hill, Norris Point, 27 July 1983, DAOM 193402 strongly associated with 193404. III causing a brooming of the branches of *Vaccinium angustifolium* Ait., Gros Morne Mtn., 20 July 1983, DAOM 193431,-2; Lobster Cove Head, 21 July 1983, DAOM 193428; trail to Western Brook Pond, 22 July 1983, DAOM 193429; Neddy Hill, Norris Point, 27 July 1983, DAOM 193404 associated with 193402; *V. vitis-idaea* L., Neddy Hill Norris Point, 27 July 1983, DAOM 193403; Lobster Cove Head, 21 July 1983, DAOM 193430. Also from Labrador, Hamilton River Valley, 54°05'N, 65°56'W, 26 July 1963, DAOM 93892.

Pucciniastrum potentillae Kom. 0,I not known; II,III on the undersurfaces of chlorotic leaves of *Potentilla tridentata* Ait., below Gros Morne Mtn., 20 July 1983, DAOM 193405. Also from Port au Choix, 8 Sept. 1951, DAOM 40881 and near St. Anthony, 3 Sept. 1951, DAOM 1951. This rust is known from Saskatchewan eastward in Canada but only on *P. tridentata*.

Pucciniastrum pustulatum (Pers.) Diet. 0,I on current year needles of *Abies balsamea* (L.) Mill., no Park records but collected at Steady Brook by A. G. Davidson, 4 July 1953, DAOM 40245 = FPF 436; II,III scattered on undersurface of leaves of *Epilobium glandulosum* Lehm., Berry Hill Campground, 17 July 1983, DAOM 193427; Berry Head, 19 July 1983, DAOM 193409; Barachois Brook E. of Glenburnie, 24 July 1983, DAOM 19894; Rocky Harbour, 27 July 1983, DAOM 193426; Beachy Point Deer Arm, Bonne Bay, 30 July 1983, DAOM 188687. Also from St. Anthony, July–Aug. 1951, DAOM 40877, 40901, 40876, 40902; Port au Choix, 8 Sept. 1951, DAOM 40879 and from Forteau Bay, Labrador, 6 Sept. 1937, DAOM 152082; on *E. palustre* L. near St. Anthony, 3 July 1951, DAOM 40882. Savile (1962) reported that morphological differences between *Pucciniastrum epilobii* and *P. pustulatum* correlated with host restriction on *Epilobium* to section *Chamaenerion* and section *Lysimachion*, respectively.

Pucciniastrum pyrolae (Pers.) Schröt. 0,I not known, expected to occur on conifers. II,III rather inconspicuous, localized on leaves of *Pyrola minor* L., Gander, 3 July 1949, DAOM 23616; Goose Bay, Labrador, 15 Aug. 1949, DAOM 23627; on *P. secunda* L., Englee south of St. Anthony, 1 Aug. 1951, DAOM 40891. Known (DAOM) on this and

other species of *Pyrola* throughout Canada and collected more rarely on *Chimaphila* and *Moneses*. The uredinia overwinter on evergreen hosts.

Pucciniastrum vaccinii (Wint.) Jørstad. 0,I on needles of *Tsuga canadensis* (L.) Carr. but not known from Newfoundland where the host is absent. It is well represented in DAOM from eastern Canada — W. P. Fraser cultured it in Nova Scotia from *Rhododendron canadense* (L.) Torr. II,III on *Vaccinium vitis-idaea* L., Gander, 23 June 1949, DAOM 23648. This rust is found widely in Canada on *Vaccinium* spp. Ziller's (1974) colour photographs of the rust on alternate hosts are excellent.

Uredinopsis americana Syd. (= *U. mirabilis* (Peck) Magn.) 0,I on undersurface of needles of *Abies balsamea* (L.) Mill., trail to Bakers Brook from Berry Hill, 31 July 1983, DAOM 193398; II,III on necrotic spots on undersurface of pinnules of *Onoclea sensibilis* L., not collected in the Park although the fern host is common in creek bed communities (Bouchard and Hay 1976). Elsewhere collected near Grand Codroy River 6 mi. (10 km) E of Millville, 22 Aug. 1949, DAOM 23580.

**Uredinopsis osmundae* Magn. 0,I on undersurface of current year needles of *Abies balsamea* (L.) Mill., James Callaghan Trail, 20 July 1983, DAOM 193399 and 11 Aug. 1978, DAOM 170456; II,III on intercostal chlorotic spots on undersurface of pinules of *Osmunda cinnamomea* L., road from visitor centre to Norris Point road, 27 July 1983, DAOM 193400, trail to Bakers Brook from Berry Hill, 31 July 1983, DAOM 193397; James Callaghan Trail, 20 July 1983, DAOM 193399; trail to Green Garden, 1 Aug. 1983 DAOM 193371; *O. claytoniana* L., trail to Green Garden, 1 Aug. 1983, DAOM 193386. Also on *Osmunda* sp., Blow Me Down Hills, Bay of Islands, 1894–1899 (by Rev. A. C. Waghorne), DAOM no number. In Canada, this fern rust occurs from Ontario eastward and has been widely collected in the Maritime Provinces (DAOM).

Uromyces armeriae (Schw.) Lévl. ssp., *hudsonicus* Savile & Connors. 0,I,II,III localized on leaves and stems of *Armeria maritima* (Mill.) Willd., trail to Green Garden, 1 Aug. 1983, DAOM 193395; foot of Table Mtn., 14 Aug. 1954, DAOM 46537 and 14 June 1956, DAOM 126888; these three collection are all from the same general area in serpentine rock rubble. Elsewhere in Canada specimens are few and widely dispersed, e.g. Coppermine, North West Territories, Great Whale River and Mt. Albert, Quebec.

Uromyces fallens Kern (= *U. trifolii-repentis* Liro var. *fallens* (Arth.) Cumm.). 0,II,III localized

and on both surfaces of leaves of *Trifolium pratense* L., Lobster Cove Head, 26 July 1983, DAOM 193374. Common on Red Clover in Ontario eastward with a few specimens from British Columbia.

**Uromyces polygoni-avicularis* (Pers.) Karst. 0,I,II,III localized on leaves of *Polygonum arenastrum* Jord. ex Bor., Corner Brook, 20 July 1950, DAOM 164938 (ex DAO); John's Beach, Bay of Islands, no date but clearly a collection by A. C. Waghorne, hence surely in the 1890s, DAOM 15915; on *P. aviculare* L., St. Anthony, 26 Aug. 1951, DAOM 54595. Abundant elsewhere in eastern Canada on *P. arenastrum* and throughout Canada on *P. aviculare*.

Uromyces trifolii-repentis Liro. 0,I,II,III localized on both surfaces of leaves and on stems of *Trifolium hybridum* L., McKays, St. Georges Bay, 9 Aug. 1949, DAOM 40533; on *T. repens* L., Mackenzie Mill Brook, East Arm of Bonne Bay, 23 July 1983, DAOM 193375. These are the most common clovers bearing this rust with rusted alsike being found throughout Canada as is White Clover. In eastern Canada *T. procumbens* L. is occasionally rusted.

Uromyces triquetrus Cke. (= *U. hyperici* (Spreng.) Curt.). 0,I,II,III all localized, mainly on the undersurface of leaves of *Hypericum canadense* L., Millville, Codroy Valley, 21 Aug. 1949, DAOM 23577. Bouchard and Hay (1976) record *H. virginicum* L. from the Park and rust occurs on it and other species of *Hypericum* elsewhere in Canada. *H. virginicum* L. takes the pycnial-aecial states of the heteroecious *Uromyces sparganii* Clint. & Peck which attacks *Acorus* and *Sparganium*. *Sparganium* spp. are also recorded from the Park (Bouchard and Hay 1976); thus this latter rust might well be found in Newfoundland (Parmelee and Savile 1954).

**Uromyces viciae-fabae* Schröt. (= *U. fabae* de Bary) 0,I on leaf undersurface; II,III on both surfaces and stems of *Vicia cracca* L., Rocky Harbour, 27 July 1983, DAOM 193373. Other hosts include *Lathyrus* spp., of which *L. palustris* L. is known for the Park, *Pisum sativum* L. and other *Vicia* spp. This rust is widespread in Canada and Cummins (1978) gives the distribution as circumglobal.

USTILAGINALES

The smut fungi are parasitic primarily on herbaceous plants as localized or systemic infections. Mature infections appear as sooty masses of spores. The spores form from the mass of

intercellular mycelium and ensure survival of the fungus through adverse conditions.

Anthracoidea atratae (Savile) Kukk. in florets appearing as globose black balls on *Carex miliaris* Michx., not found in the Park in 1983 but known from St. Anthony, 8 Aug. 1951, DAOM 28112. Species treated here were formerly considered in the genus *Cintractia* but studies by Kukkonen (1963) and by Nannfeldt (1979) indicate Brefeld's *Anthracoidea* is the correct generic designation.

Anthracoidea bigelowii Nannf. in florets of *Carex bigelowii* Torr., near Crater Lake WSW of Hebron, Labrador, July – Aug. 1954: DAOM 45535, 45540, 45544, 45545.

Anthracoidea buxbaumii Kukk. in florets of *Carex buxbaumii* Wahl. Bowater road E of Hawkes Bay, N of the Park.

Anthracoidea capillaris Kukk. in florets of *Carex capillaris* L., Port au Choix, 8 Sept. 1951, DAOM 29216; near St. Anthony, 18 July 1951, DAOM 28215; near Crater Lake WSW of Hebron, Labrador, 1 Aug. 1954 DAOM 45541; and also occasional from northern Quebec to British Columbia and the Yukon.

Anthracoidea elyanae (Syd.) Kukk. var. *elyanae* in florets of *Kobresia myosuroides* (Vill.) Fiori & Paol. near Crater Lake, WSW of Hebron, Labrador, 11 Aug. 1954, DAOM 45546. The host is arctic-alpine and the smut is common in Arctic Canada.

Anthracoidea heterospora (Lindb.) Kukk. in florets of *Carex aquatilis* Wahl., St. Anthony, July–Aug. 1951, DAOM 28109, 28110; *C. salina* Wahl., Goose Bay, Labrador, 19 Aug. 1950, DAOM 25480. The above and other species of *Carex* take this smut but specimens, in DAOM, have been collected mainly on *C. aquatilis* throughout Canada.

Anthracoidea kari (Liro) Nannf. in florets of *Carex angustior* Mack., St. Anthony, July 1951: DAOM 28114, 28115, 28145, 28146; *C. brunneescens* (Pers.) Poir., St. Anthony, July–Aug. 1951: DAOM 28228, 28229; *C. exilis* Dewey, N of Port-aux-Basques, Aug. 1963: DAOM 105923 ex TRTC 41339 and DAOM 187118 ex TRTC 41336. This smut is well represented in DAOM on other *Carex* spp. especially from northern regions of Canada.

Anthracoidea limosa (Syd.) Kukk. in florets of *Carex limosa* L., St. Anthony, 10 July 1951, DAOM 28259, 28262; Goose Bay, Labrador, July 1950, DAOM 24978, 25155 and 13 Aug. 1949, DAOM 25470; *C. rariflora* (Wahl.) Sm., St. Anthony, 5 July 1951, DAOM 28261, 28295; near Crater Lake WSW of Hebron, Labrador, 30 July

1954, DAOM 45539; *C. salina* Wahl., Goose Bay, Labrador, 21 July 1950, DAOM 28193.

Anthracoidea paniceae Kukk. in florets of *Carex leptoneura* Fern., near St. Anthony, 18 July 1951, DAOM 28239; *C. livida* (Wahl.) Willd., Sally Cove, 1 July 1972, DAOM 193376; St. Anthony, July 1951, DAOM 28122-3-4; near Lake Sims 54°05'N, 65°56'W, 26 July 1963, DAOM 93893; *C. vaginata* Tausch, St. Anthony, July 1951, DAOM 28127, 28134; near Goose Bay, Labrador 53°54'N, 79°07'W, 18 Aug. 1954, DAOM 45229.

Anthracoidea rupestris Kukk. in florets of *Carex rupestris* All. near St. Anthony, 14 Aug. 1951, DAOM 28218; Nachvak, Labrador, Aug.-Sept. 1900, DAOM 88284. Specimens at hand also from widespread locations in arctic and subarctic Canada.

Anthracoidea scirpi (Kühn) Kukk. in florets of *Trichophorum caespitosum* (L.) Hartm. ssp. *austriacum* (Pall.) Hegi (= *Scirpus c.*), 8 km. N of Port-aux-Basques, 5 Aug. 1963, DAOM 105922 ex TRTC 41338. Distribution is not as far north as the previous species but certainly into the subarctic in Canada.

Anthracoidea scirpoideae Kukk. in florets of *Carex scirpoidea* Michx., serpentine tableland SW Woody Point: 10 Aug. 1978, DAOM 169299; 28 July 1983, DAOM 193384; also from St. Anthony, July-Aug. 1951, DAOM 28266, 28271, 28273. Distributed across northern regions of the provinces and the low arctic into British Columbia, the Yukon and into Alaska.

Anthracoidea subinclusa (Koern.) Bref. in florets of *Carex miliaris* Michx., St. Anthony, 8 Aug. 1951, DAOM 28111. Other species of *Carex* which take this smut and which are known to occur in the Park (Bouchard & Hay, 1976) are *C. crawei* Dew., *C. lasiocarpa* Ehrh., and *C. vesicaria* L.

**Urocystis anemones* (Pers.) Wint. black sori embedded in leaves, petioles and stems of *Ranunculus repens* L., trail to Green Garden, 1 Aug. 1983, DAOM 193385. The smut attacks also *Anemone* spp.: *A. quinquefolia* L. in Ontario, *A. riparia* Fern. in Ontario and Quebec and *A. virginica* L. in Quebec; also *A. patens* L. var. *ludoviciana* (Bess.) Koch in western Canada. Other species of *Ranunculus* are susceptible: *R. cymbalaria* Pursh, *R. eschscholtzii* Schlecht. and *R. nivalis* L. all in western Canada but this is the first record on *R. repens* in Canada and probably in North America (Anonymous 1960; Connors 1967; Fischer 1953).

EXOBASIDIALES

These fungi attack various plant genera in the Ericaceae causing localized and systematic

infections. Whether a leaf spot, a noticeable gall or a conspicuous broom, the fungus appears on the surface of the tissue as a flat, white mat of basidia and basidiospores.

**Exobasidium canadense* Savile causes a circular leaf spot, barely or not thickened, on *Rhododendron canadense* (L.) Torr., below Gros Morne Mtn., 20 July 1983, DAOM 193377. Savile (1959) described this species, listing distribution from Quebec, New Brunswick, Nova Scotia, Prince Edward Island and New Hampshire. The description of symptom and fungus matches closely that given for *Exobasidium dubium* Rac. described in 1909 (Nannf. 1981); however, Nannfeldt did not list Savile's binomial amongst the synonyms treated and the latter's binomial is retained here.

Exobasidium cassandrae Peck forms non-thickened to concave spots, becoming red on the upper surface of leaves, or shoot infections, of *Chamaedaphne calyculata* (L.) Moench, trail to western Brook Pond, 22 July 1983, DAOM 193393. Also at Pouch Cove (both infection types present) Avalon Pen. 21 July 1981, DAOM 188717, 188718; St. Anthony, July 1951, DAOM 53100, 53101; Whiteway, Trinity Bay, 28 July 1949, DAOM 39882; N of Port-aux-Basques, 5 Aug. 1963, DAOM 99984 = TRTC 40753. Distribution in Canada ranges throughout the Maritimes to Ontario.

Exobasidium karstenii Sacc. & Trott. apud Sacc. appears white on the undersurface of much broadened, pink to blue-black leaves on scattered shoots of *Andromeda glaucophylla* Lk., Western Brook Pond, 18 July 1972, DAOM 193881 and 22 July 1983, DAOM 193379; Table Mtn., SW of Woody Point, 28 July 1983, DAOM 193378. Also from St. Anthony, 5 July 1951, DAOM 53102(a); N of Port-aux-Basques, 6 Aug. 1963, DAOM 99985 = TRTC 40749; Cape Spear, Avalon Pen., 22 July 1981, DAOM 188639. In Canada, known also from New Brunswick, Quebec and British Columbia (DAOM). Compare with *E. sundstroemii* Nannf.

Exobasidium oxycocci Rostr. ex Shear infects single shoots causing leaves to become much enlarged and whitened by the fruiting fungus on *Vaccinium oxycoccus* L., St. Anthony, 3 July 1951, DAOM 53094. Not found in the Park in 1983. It is known also on the same host (DAOM 185814) and on *V. macrocarpon* Ait. (DAOM 185812) from Nova Scotia. Note different symptom expression when *V. oxycoccus* is infected with *Exobasidium rostrupii*.

Exobasidium rostrupii Nannf. causes small, barely thickened leaf spots, bright red above on *Vaccinium oxycoccos* L., Pouch Cove, Avalon Pen., 21 July 1981, DAOM 185811. Known also on *Vaccinium macrocarpon* Ait. from Nova Scotia (DAOM 185810).

Exobasidium sundstroemii Nannf. causing leaves to become moderately broadened, pink, somewhat mottled on upper surface of *Andromeda glaucophylla* Lk., from Cape Spear, Avalon Pen. 22 July 1981, DAOM 188713. Nannfeldt (1981) notes that the mesophyll is differentiated into typical palisade, whereas in *E. karstenii*, the mesophyll of infected leaves is undifferentiated. Also known from Nova Scotia (DAOM 188638).

Exobasidium uvae-ursi (R. Maire) Juel. perennial mycelium causes noticeable brooming with the non-thickened leaves becoming bright purple-red on *Arctostaphylos uva-ursi* (L.) Spreng. No records from Newfoundland but because the fungus is widely distributed in Canada, including specimens from Nova Scotia, occurrence in our largest island province is fully expected as the host is indeed present if not abundant (DAO).

Exobasidium vaccinii Wor. localized infections as thickened leaf spots or as hypertrophied shoot tips on *Vaccinium angustifolium* Ait., Gros Morne Mtn., 20 July 1983, DAOM 193380, 193383; *Vaccinium vitis-idaea* L., Lobster Cove Head, 21 July 1983, DAOM 193382; also on *V. corymbosum* L., Cartyville, St. Georges Bay, 7 Aug. 1949, DAOM 40544. This fungus was reported on many host genera in Ericaceae (Savile 1959); however, following the review by Nannfeldt (1981) some of these collections are redispersed to other species, e.g. *Exobasidium karstenii* DAOM 53102(a) on *Andromeda*, *E. cassandrae* DAOM 53100, 53101 on *Chamaedaphne*, *E. uva-ursi* on *Arctostaphylos* DAOM 39464, 52810.

Exobasidium vaccinii-uliginosi Boud. apud Boud. & Fisch. infected leaves become enlarged, only slightly thickened, bright red, on current season shoots which appear broomed on *Vaccinium uliginosum* L., St. Anthony, 22 July 1951, DAOM 53083. Distribution elsewhere in Canada ranges northward to Baffin Island and west to the Yukon Territory (DAOM).

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Appendix 1. Host Index.

Names preceded by a dagger point symbol have not yet been found but have been noted from eastern Canada and may indeed occur in the Island Province or are mentioned otherwise in the text.

Abies

Hyalopsora aspidiotus
Lirula nervata
Melampsora epitea
Melampsorella caryophyllacearum
Pucciniastrum epilobii
Pucciniastrum goeppertianum
Pucciniastrum postulatum
Uredinopsis americanum
Uredinopsis osmundae

Acer

Phleospora aceris
Rhytisma punctatum

Acorus

† *Uromyces sparganii*

Agoseris

† *Puccinia columbiensis*
Puccinia dioicae

Agropyron

† *Claviceps purpurea*
 † *Puccinia coronata*

Agrostis

† *Puccinia coronata*

Alnus

† *Erysiphe aggregata*
Phyllactinia guttata
 † *Taphrina alni*
Taphrina robinsoniana

Amelanchier

Apiosporina collinsii
 † *Diplocarpon maculata*
 (anam. *Entomosporium m.*)
Gymnosporangium clavariiforme
Gymnosporangium clavipes
Gymnosporangium nidus-avis

Ammophila

† *Claviceps purpurea*
 † *Puccinia coronata*

Andromeda

Exobasidium karstenii
Exobasidium sundstroemii
Placuntium andromedae

Anemone

† *Urocystis anemones*

Anthoxanthum

Puccinia poae-nemoralis

Aralia

Cylindrosporium leptospermum
Nyssopsora clavellosa

Arctostaphylos†*Exobasidium uvae-ursi***Armeria***Uromyces armeriae***Aronia**†*Gymnosporangium clavipes***Aster***Coleosporium asterum**Erysiphe cichoracearum*†*Puccinia dioicae***Berberis**†*Puccinia poae-nemoralis***Betula***Atopospora betulina**Taphrina carnea***Bromus**†*Claviceps purpurea*†*Puccinia coronata***Cakile***Peronospora cakiles***Calamagrostis***Claviceps purpurea**Puccinia coronata***Caltha***Puccinia calthae**Puccinia calthicola***Campanula***Coleosporium campanulae**Puccinia campanulae***Carex***Anthracoidea atratae**Anthracoidea bigelowii**Anthracoidea buxbaumii**Anthracoidea capillaris**Anthracoidea heterospora**Anthracoidea kari**Anthracoidea limosa**Anthracoidea paniceae**Anthracoidea rupestris**Anthracoidea scirpoideae**Anthracoidea subinclusa**Puccinia caricina**Puccinia dioicae***Centaurea***Puccinia centaureae***Cerastium**†*Melampsorella caryophyllacearum***Chamaedaphne***Exobasidium cassandrae***Chimaphila**†*Pucciniastrum pyrolae***Circaea***Puccinia circaeae***Cirsium***Puccinia cnici**Puccinia punctiformis***Clintonia***Puccinia mesomejalis***Cochlearia***Albugo cruciferarum***Conioselinum***Puccinia bistortae***Cornus***Glomopsis corni**Puccinia porphyrogenita**Septoria canadensis**Septoria cornicola***Cotoneaster**†*Gymnosporangium clavipes***Crataegus**†*Diplocarpon maculata*anam. †*Entomosporium m.*†*Gymnosporangium clavipes***Cydonia**†*Diplocarpon maculata*anam. †*Entomosporium m.*†*Gymnosporangium clavipes***Dactylis**†*Claviceps purpurea***Draba**†*Albugo cruciferarum**Peronospora parisitica***Elymus**†*Claviceps purpurea**Lophodermium arundinacearum**Puccinia coronata***Empetrum***Chrysomyxa empetri***Epilobium***Pucciniastrum epilobii**Pucciniastrum pustulatum***Erigeron**†*Puccinia dioicae***Eriophorum***Puccinia angustata***Festuca**†*Claviceps purpurea*†*Lophodermium arundinaceum***Fragaria***Diplocarpon earliana*anam. *Marssonnia fragariae*†*Phyllosticta fragariicola***Galium***Puccinia punctata* var. *punctata***Gaultheria**†*Valdensinia heterodoxa***Glyceria**†*Claviceps purpurea*†*Puccinia coronata***Gymnocarpium***Hyalopsora aspidiotus*

Heracleum*Ramularia heraclei***Hieracium**† *Puccinia columbiensis*† *Puccinia dioicae**Puccinia hieracii***Hierochloe**† *Claviceps purpurea***Hordeum**† *Claviceps purpurea*† *Puccinia coronata***Hypericum**† *Uromyces sparganii**Uromyces triquetrus***Ilex**† *Rhytisma prini***Kalmia***Lophodermium exaridum**Mycosphaerella colorata***Kobresia***Anthracoidea elynae* var. *elynae***Krigia**† *Puccinia columbiensis***Juniperus***Gymnosporangium clavariiforme**Gymnosporangium clavipes**Gymnosporangium cornutum**Gymnosporangium nidus-avis***Lactuca**† *Puccinia dioicae***Lathyrus***Ascochyta pisi*† *Uromyces viciae-fabae***Leontodon***Puccinia hieracii***Ledum***Chrysomyxa ledi* var. *groenlandici**Chrysomyxa ledi* var. *rhododendri**Chrysomyxa ledicola**Chrysomyxa woronini***Liatrus**† *Puccinia poarum***Ligusticum***Puccinia bistortae***Lolium***Claviceps purpurea***Lupinus**† *Ascochyta pisi***Lycopus**† *Puccinia angustata***Malus**† *Gymnosporangium clavipes***Mentha**† *Puccinia angustata***Moneses***Chrysomyxa pirolata*† *Pucciniastrum pyrolae***Myrica***Ramularia destructiva***Nemopanthus***Ramularia nemopanthis**Rhytisma prini***Onoclea***Uredinopsis americana***Osmunda***Uredinopsis osmundae***Oryzopsis**† *Claviceps purpurea***Phalaris**† *Claviceps purpurea***Phippsia**† *Lophodermium arundinaceum***Phleum**† *Claviceps purpurea***Picea***Chrysomyxa empetri**Chrysomyxa ledi**Chrysomyxa ledicola**Chrysomyxa pirolata**Chrysomyxa woronini*† *Pucciniastrum americanum***Pinus***Coleosporium asterum*† *Coleosporium campanulae**Cronartium ribicola***Pisum**† *Ascochyta pisi*† *Uromyces viciae-fabae***Poa**† *Claviceps purpurea*† *Puccinia coronata**Puccinia poae-nemoralis**Puccinia poarum***Polygonum***Bostrichonema polygoni**Peronospora americanum**Puccinia bistortae**Uromyces polygoni-avicularis***Potentilla***Marssonina potentillae**Marssonina potentillae* var. *tormentillae*† *Phyllosticta anserina*† *Phyllosticta argentinae*† *Phyllosticta potentillae**Phragmidium andersonii**Pucciniastrum potentillae***Prenanthes***Puccinia columbiensis**Puccinia orbicula*† *Puccinia insperata*see *P. orbicula*

Puccinellia†*Lophodermium arundinaceum***Pyrola***Chrysomyxa pirolata**Pucciniastrum pyrolae***Pyrus**†*Diplocarpon maculata*anam. †*Entomosporium m.***Ranunculus***Erysiphe polygoni**Leptotrochila ranunculi*†*Pseudopeziza singularis*see *L. ranunculi**Urocysis anemones***Rhamnus***Puccinia coronata***Rhododendron***Exobasidium canadense*†*Pucciniastrum vaccinii***Ribes***Cronartium ribicola**Drepanopeziza ribis*anam. †*Gloeosporium ribis**Mycosphaerella ribis**Puccinia caricina**Septoria ribis***Rubus***Gymnoconia peckiana**Phragmidium rubi-idaei***Salix***Melampsora epitea**Rhytisma salicinum***Sanguisorba***Isariopsis bulbigera**Marssonina sennensis***Sarracenia***Glomerella cingulata***Scirpus**(see *Trichophorum*)**Senecio**†*Puccinia dioicae***Secale***Claviceps purpurea***Shepherdia***Puccinia coronata***Solanum***Synchytrium endobioticum***Solidago***Coleosporium asterum**Puccinia dioicae***Sorbus***Diplocarpon maculata*anam. *Entomosporium maculatum**Gymnosporangium clavipes*†*Gymnosporangium cornutum***Sparganium**†*Uromyces sparganii***Spergularia***Albugo lepigoni***Spartina**†*Claviceps purpurea***Stellaria***Melampsorella caryophyllacearum***Stipa**†*Claviceps purpurea***Taraxacum***Puccinia hieracii**Puccinia variabilis***Taxus***Sphaerulina taxicola***Trichophorum***Anthracoidea scirpi*†*Puccinia angustata***Trientalis***Ramularia magnusiana**Septoria increscens***Trifolium***Uromyces fallens**Uromyces trifolii-repentis***Triticum**†*Claviceps purpurea***Tsuga***Pucciniastrum vaccinii***Tussilago***Puccinia poarum***Vaccinium***Exobasidium oxycocci**Exobasidium rostrupii**Exobasidium vaccinii**Exobasidium vaccini-uliginosi**Pucciniastrum goeppertianum**Pucciniastrum vaccinii**Ramularii vaccinii**Valdensinia heterodoxa***Veronica***Puccinia albulensis***Viburnum***Cercospora varia**Puccinia linkii***Vicia**†*Ascochyta pisi**Uromyces viciae-fabae***Viola***Puccinia violae*

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Colony Size and Reproductive Biology of the Bank Swallow, *Riparia riparia*, in Saskatchewan

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Bank Swallows (*Riparia riparia*) nesting along the Qu'Appelle River valley in southeastern Saskatchewan in 1980 and 1981 had a mean colony size of 7.7 nests, which is much smaller than reported from other areas. The small size of colonies is due to the absence of large banks. Clutch size, nest success, and number of young fledging per nest in this population indicate a high breeding success comparable to other areas, showing that large colonies are not necessary for high reproductive success.

Key Words: Bank Swallow, *Riparia riparia*, colony, productivity, Saskatchewan.

Bank Swallow, *Riparia riparia*, colonies on the Canadian prairies averaged only five nests compared with a Canadian average of 42 nests (Erskine 1979). Colonies on the Canadian prairies were also much smaller than in Britain, where the mean colony size is 42 nests (Morgan 1979), and in Michigan, where 40 percent of colonies contained more than 50 nests (Hoogland and Sherman 1976). There have been no previous studies of Bank Swallow nesting biology in the area of small colonies on the Canadian prairies.

Colonial nesting has been considered advantageous to Bank Swallows because it allows group detection and defence against predators (Hoogland and Sherman 1976) or facilitates foraging (Emlen and Demong 1975). If either or both of these hypotheses are correct, Bank Swallows can be expected to have reduced their reproductive fitness by nesting in small colonies. In 1980 and 1981, as part of a study of colony site selection of Bank Swallows, we collected data on nest characteristics, clutch size, and productivity of Bank Swallows nesting along the Qu'Appelle River in southeastern Saskatchewan.

Study Area and Methods

We studied Bank Swallows along the Qu'Appelle River valley around, and downstream of, Katepwa Lake (50°40'N, 103°38'W). The Qu'Appelle River valley is a glacial meltwater channel which, in this area, is almost 2 km wide and 75 to 90 m deep. Much of the valley bottom has been developed for crop cultivation and hayland, although it includes some pasture land, the small meandering Qu'Appelle River, and a series of

marshes. These wetlands and 1607-ha Katepwa Lake appeared to provide an abundant supply of insect food.

During 1980 and 1981 we physically inspected all possible locations within the 7736-ha study area, including natural banks along the lakeshore, the Qu'Appelle River, and tributary creeks as well as banks created by gravel mining, road construction, garbage pits and building sites, to locate nesting Bank Swallows. We collected physical data on each nest tunnel in each colony (Hjertaas 1984) including length, height above the bank base, and distance from the bank top and data on the characteristics of the banks themselves.

Nest contents were examined using a wooden rod with a flashlight bulb and dental mirror at the end (Petersen 1955; Hoogland and Sherman 1976). This allowed observation of nests in straight tunnels less than 80 cm deep. Some observations were missed in 1980, as early models of the light stick were not effective. In those cases observations of Bank Swallows entering tunnels were considered to indicate active nests.

We repeated observations of nest contents at approximately seven-day intervals at a series of accessible colonies to determine nest success. Nest contents were easily visible during egg laying and early incubation. By late incubation the nests contained large numbers of feathers; consequently, egg counts in this period were often only minimum estimates. Nestlings tended to huddle together and were also difficult to count. In 1981 we captured young which were ready to fledge using a simple trap consisting of a 30-cm-long cardboard tube placed in the tunnel mouth with a nylon stocking

TABLE 1. Bank Swallow colony size in the Qu'Appelle River valley, Saskatchewan, in 1980 and 1981.

Nests in colony	1980	Number of Colonies 1981	Combined	Number of nests
1	8	7	15	15
2	2	4	6	12
3	7	4	11	33
4	2	3	5	20
5	1	4	5	25
6	2	3	5	30
7	3	1	4	28
8	2	1	3	24
9	0	1	1	9
10	1	0	1	10
11	4	0	4	44
12	1	0	1	12
13	1	2	3	39
15	1	0	1	15
16	1	4	5	80
17	1	1	2	34
18	0	1	1	18
20	1	1	2	40
24	1	1	2	48
27	1	0	1	27
48	0	1	1	48
	40	39	79	611

over the outside end. Captured young were held while the nest was inspected to count any remaining nestlings. Most counts of fledglings were obtained in this way.

Results

Colony Size

During 1980 and 1981 we located 79 Bank Swallow colonies on 60 banks. Only 19 banks (32%) were used both years. Colonies ranged in size from 1 to 48 nests with a mean of 7.7 nests per colony. Although almost 40% of the colonies were very small with 1, 2 or 3 nests (Table 1), most Bank Swallows nested in the larger colonies, with 68% of all nests in colonies of 10 nests or more. The mean of 7.7 nests per colony is significantly smaller than those found in other studies in eastern North America and Britain, and the range is much smaller than the range of 10 to 300 nests summarized by Emlen and Demong (1975).

Physical Characteristics of Nests and Banks

The range of tunnel lengths noted in this study lies inside the range reported by other authors. The 545 tunnels measured had a mean length of 63.6 cm (S.D. = 19.3 cm) and ranged from 15 to 145 cm in length. Mean tunnel length was similar to the 65.6 cm reported for 29 nest holes by

Hickling (1959) and 71 cm reported for 89 nests by Stoner (1936). Wickler and Marsh (1981) reported a mean of 90 cm for 34 nest tunnels in sand, and Beyer (1938) reported averages of 76 cm for nest tunnels in sand and 40 cm for those in clay. We noted a similar trend toward longer tunnels in sands and fine gravels than in fine-textured soils.

Mean height of nest entrances above the talus or the base of the bank was 111.2 cm (S.D. = 49.1 cm; range from 25 to 340 cm). This is much lower than the mean of 290 cm reported for English nests (Morgan 1979). Nest entrances were located an average of 64.5 cm (S.D. = 45.5 cm) below the top of the bank but range from 10 to 320 cm.

Freer (1977) showed that Bank Swallow colonies decline as banks age. This appeared to be caused by the bank's shrinking due to slumping. We believe our banks are relatively small to begin with and so can support only small colonies. The mean bank height and bank length of 25 much larger colonies in Pennsylvania and Vermont, with a mean of 95.4 holes (Spencer 1962) compared to our 7.7 active nests, were, at 3.16 m and 55.2 m, substantially larger than the 1.84 m and 30.9 m for our 60 occupied banks. No banks in our study were as large as those shown in photographs by Petersen (1955).

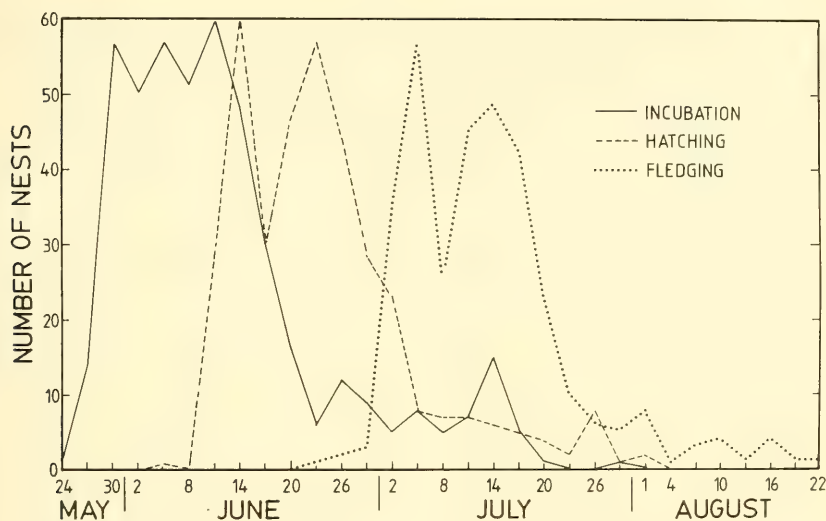


FIGURE 1. Chronology of Bank Swallow nesting in the Qu'Appelle River valley, Saskatchewan. Plots show the total number of nests combined for 1980 and 1981 starting incubation (solid line), hatching (large dashes) and fledging (small dashes) by three-day period.

The much lower height of nest tunnels in our study compared to those studied in Britain suggest our banks are smaller, especially since Morgan (1979) observed that burrows were placed higher when higher banks are available. We noted a strong correlation of 0.727 ($p < 0.001$) between bank height and height of the nest entrance. Many of our colonies consisted of a single horizontal row of nests approximately 1 m above the bank base and 30–40 cm from the bank top. There was no room for clusters of nests such as those described by Petersen (1955) and Hoogland and Sherman (1976). Thus, we conclude that the small colony size in our study was due to the lack of large banks rather than to other environmental deficiencies.

Nest Chronology

We determined date of start of incubation, date of hatching, and date of fledging for 464, 383, and 326 nests, respectively. The mean, mode and first and last dates for each variable were similar for 1980 and 1981 (Hjertaas 1984), so we combined all the data. The first pairs began incubating during the last week of May (Figure 1). Stoner (1936) reported the first eggs at Oneida Lake in New York on 19 May. If five days are needed to lay a clutch of five, the first New York Bank Swallows started incubating about 22 May, only two days earlier than in this study. The peak of starting incubation in our study area extended from 29 May to 11 June

and incubation of the latest clutch began 29 July 1981. Petersen (1955) reported the start of the latest clutch in Wisconsin on 5 July, from which incubation would begin about 10 July. In New York, Stoner (1936) reported fresh eggs as late as 13 July. Thus both our latest pair and our latest successful pairs, which started incubating on 29 July 1981 and 17 July 1980 and 1981, were later than other reports and 4–7° further north.

Hatching and fledging follow, about fourteen and thirty-four days after initiation of incubation, respectively. The earliest young left the nest on 24 June 1980. A peak in fledging occurred around 4 July each year, with a high fledging rate continuing until 20 July (Figure 1). After this date the number of active nests at the colonies dropped rapidly with the latest nests fledging on 20 August 1980 and 21 August 1981.

Late-nesting Bank Swallows have a reduced probability of raising a brood. The mean start of incubation for successful nests is 9 June compared to 19 June for unsuccessful nests. The difference is statistically significant ($p < 0.001$). Four of five nests initiated after 15 July in 1980 and five of six initiated after 15 July in 1981 failed.

Clutch Size

Clutch size is calculated from 167 clutches counted in 1981. The mean clutch size in 1981 was 5.0 (S.D. = 0.84; range from 2 to 7; $N = 167$), but

TABLE 2. Clutch size of Bank Swallow nests in the Qu'Appelle River valley, Saskatchewan, in 1981.

Eggs in clutch	Number of nests
2	1
3	5
4	36
5	77
6	47
7	1

clutches of 4, 5 and 6 eggs were most common (Table 2). Clutch size in this study was similar to that reported for Michigan and slightly higher than those reported in New York, Wisconsin, and Britain (Table 3). Clutch size had a strong negative correlation with day of start of incubation ($\text{corr} = -0.547, p < 0.001$). The regression line declines to 0 on 29 July (Figure 2), which was the latest date on which a pair began incubation. Successful nests started with significantly larger average clutches than unsuccessful nests, 5.2 compared to 4.3 ($p < 0.001$). That difference was probably due, at least in part, to the high failure rate of late nests which had small clutches.

Number of Young Fledged

An average of 4.4 (S.D. = 0.990) young fledged from the 91 successful nests from which we obtained accurate counts. Five was the most common number of fledglings (Table 4). These data may be biased towards larger broods, as we could not be certain if one or two young observed in a nest represented the entire brood or if several young had already left. At 46 nests both the clutch size and number of young fledging were determined. Of the 241 eggs in those nests, 218 or 90.5% resulted in successfully fledged young.

Nest Success

We combined data from 498 nests with repeat observations to calculate Mayfield's index of nest success (Mayfield 1961; Johnson 1979). Nest success was significantly ($p = 0.01$) higher in 1981

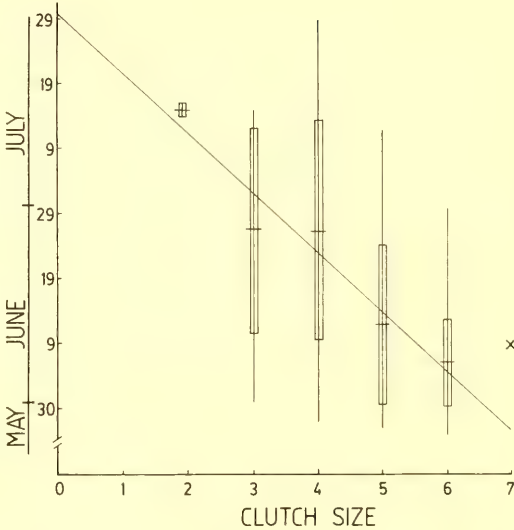


FIGURE 2. Relationships of clutch size to date of start of incubation in Bank Swallows nesting in the Qu'Appelle River valley, Saskatchewan, during 1980 and 1981. The vertical line represents the range, horizontal line the mean, and one standard deviation on each side of the mean is represented by a vertical bar. The lone clutch of seven is represented by an x. A diagonal line represents the linear regression.

(index of 0.0113) than in 1980 (index of 0.0206). That difference was partly due to greater nest loss from gravel mining in 1980 (Hjertaas 1984), but it might also reflect the higher percentage of late nests observed in 1980.

An average Bank Swallow nest must survive 5 days of egg laying, 14 days of incubation, and 20 days with young, a total exposure of 39 days. The probability of a nest surviving that period is calculated by taking the probability of surviving for one day (1 — Mayfield's Index) to the 39th power. By that calculation a Bank Swallow starting egg laying had a 44.4% chance of fledging young in 1980 and a 64.2% chance in 1981.

TABLE 3. Bank Swallow clutch size as reported in several studies.

Mean clutch	Most common clutch	Range	Study area	Reference author
4.98	-	3-8	Michigan	Hoogland and Sherman (1976)
4.8	5	2-6	Wisconsin	Petersen (1955)
4.8	5	2-7	New York	Freer (1977)
4.78	5	2-6	Great Britain	Morgan (1979)
5.0	5	2-7	Saskatchewan	This study

TABLE 4. Number of young fledged from 91 successful Bank Swallow nests in the Qu'Appelle River valley, Saskatchewan, in 1981.

Number of young fledging	Number of nests
2	4
3	12
4	26
5	40
6	9

Discussion

The advantages conferred by social foraging have been suggested to be one of the impelling forces in the evolution of coloniality (Emlen and Demong 1975). The same authors relate the decline in nest success of late-nesting Bank Swallows to the small colony size late in the nesting season and the consequent loss of those social advantages. If reproductive fitness were directly affected by colony size the small colonies on the Canadian prairies should have had reduced productivity compared to larger colonies in other areas as measured by indices such as clutch size, nest success and fledging rate.

Clutch size in this study (mean 5.0, range 2-7) was as large as, or larger than, that reported elsewhere (Table 3). Of the 611 nests observed, 380 (62%) were successful and 1719 fledglings were produced for a mean of 2.8 fledglings per nesting pair. The reproductive success from eggs laid in 46 successful nests was 90.5%, and 58% of all eggs laid produced fledged young. Thus the population parameters which were measured indicated high breeding success.

There are few published data on breeding success in Bank Swallows. Our data are comparable with those of Emlen and Demong (1975) for 12 Bank Swallow colonies in Tomkins County, New York. From their graphs, reproductive success — the percentage of eggs which produce fledglings — ranged from 47% to 78% and the mean number of fledglings produced per pair ranged from 2.3 to 3.6.

The success of our small colonies during the main breeding season shows that small colony size itself is probably not the cause of the reduced nest success of late-nesting Bank Swallows observed by Emlen and Demong (1975) and in this study. Possible causes of the decline in productivity of late-nesting pairs include declines in food availability, deteriorating environmental conditions, and larger numbers of inexperienced first year birds among the late nesters. However, these problems were beyond the scope of our study.

Our evidence indicated that Bank Swallows along the Qu'Appelle River valley nested in small colonies with good reproductive success. Why, then, do Bank Swallows nest in large colonies elsewhere? We see two possibilities. Perhaps nesting in large groups is usually advantageous, but some environmental factors in the Qu'Appelle River valley, such as abundant food or absence of certain predators or competitors, compensate for any reduction in fitness that may result from nesting without large numbers of conspecifics. Alternately, the principal benefit of large colonies may be the opportunity to use the bank which offers greatest protection from predators or convenience to foraging areas. In this case Bank Swallows should concentrate on the "best" bank if suitable unoccupied nest space remains. If the only spaces remaining are too close to the ground or are otherwise unsuitable, choosing a nest site on a different bank would be the best option. Strategies such as predator mobbing (Hoodland and Sherman 1976) and socially facilitated foraging could then be secondary adaptations of living in large groups, and may be relatively unimportant in an area of small colonies.

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Significant Aggregations of the Endangered Right Whale, *Eubalaena glacialis*, on the Continental Shelf of Nova Scotia

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Stone, Gregory S., Scott D. Kraus, John H. Prescott, and Katherine W. Hazard. 1988. Significant aggregations of the endangered Right Whale, *Eubalaena glacialis*, on the continental shelf of Nova Scotia. *The Canadian Field-Naturalist* 102(3): 471-474.

Sixty-one Right Whale sightings (totaling 230 whales) were made near Browns and Baccaro banks on the Nova Scotian shelf during surveys conducted from 1981 to 1985. Fifty individual Right Whales were identified and 34 of these were re-sighted at other locations including four from the of Georgia-Florida coast ($n = 25$), 20 from the Bay of Fundy ($n = 130$), and 10 from the southern Gulf of Maine ($n = 55$). Forty percent of the Right Whales sighted were in surface-active-groups, a behavior possibly related to courtship activity. Eight defecations were observed; the two samples collected contained undigested mandibles of the copepod *Calanus finmarchicus*. These results indicate the Nova Scotian continental shelf is a summer-fall Right Whale habitat used for social activities and feeding.

Key Words: Right Whale, *Eubalaena glacialis*, migration, Nova Scotia, continental shelf.

The continental shelf extends east and southeast of Nova Scotia for 150 to 200 nautical miles. Five submarine banks (Browns, Baccaro, Roseway, Lehave and Emerald) with mean depths of about 25 m form the southern portion of the Scotian shelf. During the past thirty years there have been consistent sightings of sometimes numerous North Atlantic Right Whales, *Eubalaena glacialis*, at the shelf edge and near these banks. The Nova Scotian shelf appears to be of special significance to the North Atlantic population of Right Whales. It may be especially important to preserve this habitat because this species is one of the rarest of the large whales.

From 1981 to 1985 ship and aerial surveys were conducted in an area near Browns and Baccaro banks to examine Right Whale distribution and relative abundance and to identify individuals. These data have been integrated with studies of Right Whales at other locations including the Bay of Fundy (Kraus et al. 1983), Mount Desert Rock (Rivers and Mullane 1984), Cape Cod Bay, Southern Georges Bank (Winn et al. 1981; Kraus et al. 1982), and the only known wintering ground off the Georgia-Florida coast (Kraus et al. 1986a).

This paper presents results from the surveys on the Nova Scotian shelf and other sightings from that area.

The first record of a Right Whale in Nova Scotian waters is that of a dead animal in October 1954 at 45° 52' N, 63° 40' W, which was estimated to be 11-12 m in length (Sergeant et al. 1970).

Sutcliffe and Brodie (1977) examined the log books of catcher boats working from a whaling station at Blandford, Nova Scotia, for the years 1966-72. The whaling season was from May to November and the effective range of the boats extended beyond the Scotian shelf. All kills and occasional sightings of other whales were recorded in the log books. The records indicate that most whales occurred either at the shelf edge or along the edges of submarine banks. Of the 416 reported sightings, 27 were of Right Whales. Seven were between Browns and Baccaro banks and twenty were on the Scotian shelf, principally northeast of these banks. Mitchell (1974), working with the whaling vessels, tagged two Right Whales in 1966 and two in 1971 on the Nova Scotian continental shelf.

Records of the Sea Education Association's (SEA) R/V *Westward* have also been examined for Right Whale sightings. During summers, the *Westward* frequently cruises between Maine, Nova Scotia, and Newfoundland. In 1973 they sighted five Right Whales between Browns and Baccaro banks on 13 and 14 September (Balcomb 1973).

The Cetacean and Turtle Assessment Program (CETAP) of the University of Rhode Island conducted an aerial survey along the southern and southwestern continental shelf of Nova Scotia during August 1980 (Winn 1982). This survey searched areas where Right Whales had been reported in the Blandford whaling logs (Sutcliffe and Brodie 1977). Right Whales were observed in

only one area of the Scotian shelf, between Browns and Baccaro banks. Four sightings made over four days were at the same location ($42^{\circ}48'N$, $65^{\circ}18'W$), and the largest count of 46 Right Whales was on 25 August 1980.

These records indicate that Right Whales are regularly present on the Scotian shelf from June through October. Two of the reports (Sutcliffe and Brodie 1977; Winn 1982) suggest that Right Whales congregate in specific regions. The whaling vessels covered much of the Nova Scotian shelf but only sighted Right Whales on the southwestern portion near the shelf edge and near Browns, Baccaro, Roseway, LeHave and Emerald banks. Winn (1982) systematically surveyed the southern and southwestern portions of the shelf with a 7%–10% coverage and observed Right Whales only between Browns and Baccaro banks.

The 46 right whales seen during this survey made up the second largest concentration of North Atlantic Right Whales reported in modern times. The largest aggregation consisted of over 70 animals in Cape Cod Bay during April 1971 (Watkins and Schevill 1982). Because of the consistency of sightings and large concentrations in the Browns and Baccaro banks area, the following survey efforts were concentrated there.

Methods

Vessel Surveys

During July and August of 1981–1985 seven vessel surveys were conducted in the Browns/Baccaro banks area (Figure 1). The survey cruises transected areas where Right Whales had been reported in recent literature and stopped to photographically identify individual whales



FIGURE 1. Location of the study area between Browns and Baccaro banks in relation to Cape Sable, Nova Scotia.

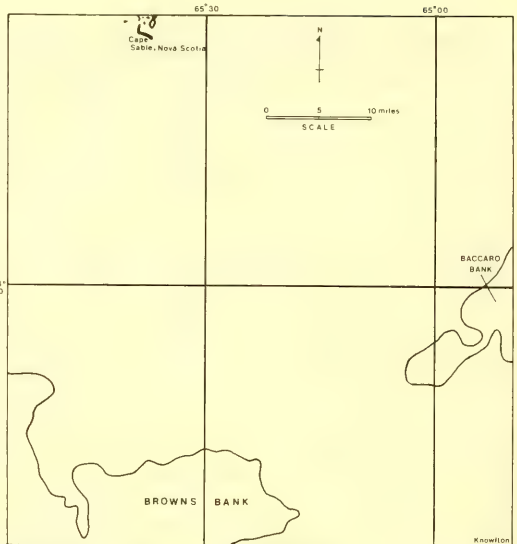


FIGURE 2. Observer photographing Right Whale for individual identification during vessel survey.

(Figure 2). All sightings, positions and behaviors were recorded on standard forms.

Aerial Surveys

Four aerial surveys were conducted in the same area in 1981, 1982, 1983 and 1984. Surveys were flown utilizing standard aerial survey procedures (Winn 1982) and were designed such that the known historical location of Right Whale concentrations would be at the center of the area surveyed. Track lines were parallel and spaced at 2–5 nautical mile intervals. Each track line extended beyond the range of Right Whale concentrations by 10–15 nautical miles.

Both aerial and vessel transects were interrupted to photograph and count Right Whales, then resumed at the point of departure when photo-identification procedures were completed. Vessels would slowly maneuver around a whale until both left and right sides of its head, callosity patterns, and other distinguishing features had been photographed. During aerial surveys, observers photographed rostral callosity patterns and views of the entire dorsal surface of the animal's body. Thirty-five mm cameras with 200 mm to 300 mm telephoto lenses and Ektachrome 400 and Kodachrome 64 color transparency films were used.

All photographically identified Right Whales were catalogued and coded according to callosity patterns and body scars. Composite drawings that

TABLE 1. Resightings of Right Whales identified from the Nova Scotian continental shelf, 1980–1985. Values of “n” represent total number of whales identified from that area.

Total no. of Right Whales identified from Nova Scotian Shelf	Nova Scotian shelf, prev. n = 50	Bay of Fundy n = 130	Southern Gulf of Maine n = 55	Georgia-Florida coasts n = 25
50	4	20	10	4

included all identifying features were created for each whale and compared with other composite drawings of Right Whales in the New England Aquarium’s composite catalog. Final matching was done using original slides and photographs. Details of the methods used to catalog and match individual Right Whales are described in Kraus et al. (1986b).

Results

The combined ship and aerial surveys resulted in 61 sightings (230 whales). All sightings were within 15 nautical miles of each other and centered on 42°56’N, 65°21’W. During each day, sightings of most whales were concentrated within 2–3 nautical miles of one another. The largest aerial count of 32 whales was made on 10 August 1983. The largest shipboard count, on 4 August 1984, was of 45 whales. Other daily totals ranged from 8 to 20 whales. No Right Whales were seen during the only winter survey in February 1982.

Fifty individual whales were identified from photographs of callosities and other natural patterns and scars on the body. Comparison of these photographs with the New England Aquarium catalog of identified whales revealed 34 matches with other locations and four year-to-year matches within the Browns/Baccaro region (Table 1).

Twenty-one surface active groups (SAGs) were observed, with a mean group size of 4.75 whales (sd = 2.78). A SAG is defined as an event during which two or more whales are observed touching while rolling at the surface, positioning belly to belly, stroking each other with flippers, and always maintaining close positioning, usually within a Right Whale’s body length of each other. The largest SAG, with more than 13 whales involved, was observed during an aerial survey on 10 August 1983.

Frequently, one member of the SAG would float ventral side up at the surface. Whenever sex was determined, the upside-down whale was always female. Although intromission was not observed, similar behaviors in groups of Right Whales have been described as courtship and mating (Kraus et al. 1983; Payne and Dorsey 1983; Donnelly 1967).

Another consistent feature of these sightings was the low number of calves, only two (4% of total

identified whales) during the five-year study. This contrasts with the 37 (12% of total identified whales) calves seen in the Bay of Fundy during the same period.

Right Whales defecated on eight occasions. The fecal materials were reddish-brown in color. During vessel surveys in 1983 and 1984 samples were collected. Microscopic analysis revealed undigested exoskeleton parts of the copepod *Calanus finmarchicus*.

Discussion

The sightings chronicled above show a consistent record of Right Whales’ inhabiting the Nova Scotian shelf for at least the last nineteen years, 1966–1985. There is only one record previous to 1966, a dead animal in 1954. We know of no other earlier records. Research in 18th and 19th century whaling log books has not revealed historical hunting grounds on the Scotian shelf (Reeves and Mitchell 1983).

Minimum counts from the Nova Scotian shelf sightings have ranged between 8 and 46 whales. With total population estimates of 200 to 300 Right Whales in the western North Atlantic (Mitchell 1973; Winn et al. 1981; Table 1 of this paper), the highest count of animals observed on the Nova Scotian shelf represents at least 15% to 25% of the estimated population. The seasonal distribution of sightings for all years extends from June to late October, with most in July and August. The temporal pattern of distribution and the number of animals observed indicate the Nova Scotian continental shelf to be a summer–fall habitat for Right Whales.

Records for the rest of the western North Atlantic Ocean indicate that some Right Whales winter off the coast of the southeastern United States during winter months. Spring and early summer concentrations have been consistently observed in Cape Cod Bay and the Great South Channel during the last 10 to 20 years (Watkins and Schevill 1982). In July, they appear to arrive simultaneously in the Bay of Fundy and on the Nova Scotian continental shelf; they probably leave both locations near the end of October.

Resightings of Nova Scotian shelf whales at other locations where there has been consistent effort to identify individuals suggest that these Right Whales belong to one stock of animals which mix between the Nova Scotian shelf, the Bay of Fundy, the southern Gulf of Maine, and the coasts of Georgia and Florida (Table 1). Fifteen percent of the whales identified in the Bay of Fundy ($n = 130$) have also been seen on the Nova Scotian shelf; eighteen percent of the whales identified from the southern Gulf of Maine ($n = 55$) have been seen on the Nova Scotian shelf. These similar resighting percentages suggest that the Nova Scotian shelf is probably utilized at equal frequencies by whales seen at these other Right Whale habitats.

Several behavioral features are apparent in these data. 1) SAGs were observed during 40% of the sightings. Winn (1982) also recorded a high incidence of SAGs in 1980 (60%). While it is not yet certain whether these behaviors involve intromission leading to conception, it is clear that the whales are involved in group sexual behaviors while on the Scotian shelf. 2) The whales are feeding. The Scotian shelf is known to be an area of high productivity with suitable prey species for Right Whales (Brodie et al. 1978). Our observations of defecation confirm the use of this area for feeding. 3) The low number of calves (2%) in our data is noteworthy. Calves are regularly sighted in all other areas where North Atlantic Right Whales are known to occur. In Cape Cod Bay and the Great South Channel, Right Whale calves constitute 14% of the identified whales; in the Bay of Fundy calves constitute 12% of the identified whales; and off the coast of Georgia-Florida, the calves are 29% of the identified whales (Kraus et al., 1986). According to our findings, mothers with calves apparently show preference for these other areas.

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New Distributional Records for the Minnows *Hybognathus hankinsoni*, *Phoxinus eos*, and *P. neogaeus* in Manitoba

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S. M. Harbicht, W. G. Franzin, and K. W. Stewart. 1988. New distributional records for the minnows *Hybognathus hankinsoni*, *Phoxinus eos*, and *P. neogaeus* in Manitoba. *Canadian Field-Naturalist* 102(3): 475-484.

New collections and previously unpublished reports extend the documented ranges of *Hybognathus hankinsoni* (Brassy Minnow), *Phoxinus eos* (Northern Redbelly Dace), and *P. neogaeus* (Finescale Dace), in Manitoba. The ranges of all three species are more extensive than indicated by previously published information.

Key Words: Fish distribution, *Hybognathus hankinsoni*, *Phoxinus eos*, *Phoxinus neogaeus*, Manitoba.

The known ranges of the Brassy Minnow, *Hybognathus hankinsoni* (Hubbs), the Northern Redbelly Dace, *Phoxinus eos* (Cope), and the Finescale Dace, *P. neogaeus* (Cope) were most recently summarized by Scott and Crossman (1979) and by Lee et al. (1980). Sampling of Manitoba lakes and streams during the last several years by federal and provincial government biologists and by researchers from the University of Manitoba and the University of Winnipeg has increased our knowledge of the distributions of these species in Manitoba. This paper is a compilation of these new records plus a few old, unpublished records uncovered during our searches of previously collected material. Wherever possible the original collector's name, number of specimens collected, sampling date and location, and the location of stored specimens, if any, were determined.

The revised distributions in Manitoba of *Hybognathus hankinsoni*, *Phoxinus eos*, and *P. neogaeus* are presented in Figures 1, 2 and 3, respectively, and in Tables 1, 2 and 3, respectively. Previously published records were reviewed and are included in each case to indicate the extent of the new information. Where possible, verification of the species was conducted by the authors, as noted in the tables, and for the remaining information the identification of the specimen was assumed to be correct.

Hybognathus hankinsoni is now known to occur in four drainages: Dauphin Lake, Lake Winnipegosis, Pembina River, and the Assiniboine River in Manitoba with the most northerly location being Garland Creek (51°39'N, 100°29'W). The northern limit for the species was extended about 60 km by

this collection. The distribution of this species (Figure 1) remains strangely disjunct within the province, occurring in only two areas and seemingly not occurring in apparently suitable habitats elsewhere. Future collections with particular attention to the environments of sample sites may rationalize this picture.

The distributions of *Phoxinus neogaeus* and *P. eos* have also been extended significantly northward and westward from the previously known areas in the southeastern corner of the province. Unlike *Hybognathus* spp., these two species, aside from a single collection each, appear to be headwater species occurring in forested highlands or wetlands. Both species of *Phoxinus* must be considered rare in the province, although they may be locally abundant. *P. neogaeus* has been found in seven drainages to date: Lake Winnipegosis, Dauphin Lake, Lake Manitoba, Assiniboine River, Lake Winnipeg, Winnipeg River and the Red River in Manitoba with the current northern limit at North Duck River (52°01'N, 100°43'W). *P. eos* has been found in six drainages: Winnipeg River, Lake Winnipeg, Souris River, Dauphin Lake, Lake Manitoba and the Red River with a current northern limit in the province at Vermilion River (51°01'N, 100°10'W).

These records probably do not represent the final distributions of these species in Manitoba. Additional areas in which all three species may occur include the Turtle Mountain area, the south slope of the Riding Mountains, the Duck Mountains, the Porcupine Mountains and possibly the Pasquia Hills area south of The Pas, Manitoba. Certainly, these Manitoba collections are not near the known northern limits for these

TABLE 1. Known distribution of *Hybognathus hankinsoni* in Manitoba. Collections above the line are previously published (Scott and Crossman 1979; Lee et al. 1980).

Date of collection (1900s)	Location	Drainage system	Geographic coordinates	Collector	No. of Specimens	Specimen storage location	Authors' verification
24/06/49	Little Pembina River	Pembina River	49° 12'N 99° 49'W	A. H. Kooyman	1	ROM ¹ 14839	
-/-/(50s)	Assiniboine River	Assiniboine R.	51° 25'N 101° 31'W	J. J. Keleher	2	-	
23/-08/54	Pembina River	Pembina River	49° 15'N 99° 40'W	J. J. & G. M. Keleher	8	ROM 16563	
11/07/54	Vermilion River	Dauphin Lake	51° 11'N 99° 50'W	J. J. Keleher	8	ROM 16564	
23/07/55	Pembina River	Pembina River	49° 11'N 99° 48'W	W. B. & M. G. Scott	153	ROM 17544	
23/07/55	Pelican Lake	Pembina River	49° 20'N 99° 32'W		5	ROM 18397	
27/06/70	Pelican Lake	Pembina River	49° 22'N 99° 35'W	C. G. Gruchy	-	NMC ² 700172	
summer/70	Mink River	Dauphin Lake	51° 23'N 100° 33'W	R. Moshenko ⁵	abundant	" "	not available
summer/70	Mink River	Dauphin Lake	51° 24'N 100° 20'W	R. Moshenko	abundant	" "	"
summer/70	Mink River	Dauphin Lake	51° 24'N 100° 05'W	R. Moshenko	abundant	" "	"
3/07/74	Edwards Creek	Dauphin Lake	51° 03'N 100° 03'W	A. H. Kooyman and R. Hutchison ⁶	1	" "	
20/07/05	Vermilion River	Dauphin Lake	50° 53'N 100° 16'W	A. H. Kooyman	3	" "	
summer/76	Mink River	Dauphin Lake	51° 22'N 100° 30'W	M. Gaboury ⁷	1	" "	
summer/76	Mink River	Dauphin Lake	51° 22'N 100° 05'W	M. Gaboury	1	" "	
11/06/80	Garland Creek	L. Winnipegosis	51° 39'N 100° 29'W	W. Franzin & S. Harbicht	1	DFO ³ FWI	x
29/06/82	Vermilion River	Dauphin Lake	51° 01'N 100° 10'W	" "	1	" "	x
29/06/82	Crawford Creek	Dauphin Lake	51° 01'N 99° 52'W	" "	2	" "	x
29/06/82	Turtle River	Dauphin Lake	51° 04'N 99° 31'W	" "	20	" "	x
11/08/82	Mink River	Dauphin Lake	51° 24'N 100° 29'W	" "	1	" "	x
11/08/82	Edwards Creek	Dauphin Lake	51° 07'N 100° 04'W	" "	3	" "	x
11/08/82	Ochre River	Dauphin Lake	50° 56'N 99° 49'W	W. Franzin & S. Harbicht	6	" "	x
11/08/82	Ochre River	Dauphin Lake	50° 54'N 99° 49'W	" "	19	" "	x
11/08/82	Turtle River	Dauphin Lake	50° 57'N 99° 32'W	" "	58	" "	x
11/08/82	Turtle River	Dauphin Lake	51° 03'N 99° 32'W	" "	6	" "	x
summer/82	Valley River	Dauphin Lake	51° 17'N 99° 55'W	M. Gaboury ⁸	4	not available	
summer/82	Valley River	Dauphin Lake	51° 13'N 100° 20'W	" "	12	" "	
summer/82	Silver Creek	Dauphin Lake	51° 12'N 100° 38'W	" "	228	" "	
summer/82	Silver Creek	Dauphin Lake	51° 16'N 100° 51'W	" "	3	" "	
summer/82	Pleasant Valley	Dauphin Lake	51° 09'N 100° 49'W	" "	19571	" "	
16/05/83	Ochre River	Dauphin Lake	51° 03'N 99° 46'W	W. Franzin & S. Harbicht	1	DFO FWI	x
10/06/83	Ochre River	Dauphin Lake	50° 58'N 99° 47'W	" "	2	" "	x
05/07/83	Ochre River	Dauphin Lake	50° 56'N 99° 49'W	" "	1	" "	x

Continued

TABLE 1. *Concluded.*

Date of collection (1900s)	Location	Drainage system	Geographic coordinates	Collector	No. of Specimens	Specimen storage location	Authors' verification
18/08/83	Ochre River	Dauphin Lake	50°56'N 99°49'W	W. Franzin & S. Harbicht	1	"	x
17/09/83	Pembina River	Pembina River	49°05'N 98°12'W	K. W. Stewart	1	UMZ ⁴	x
20/10/83	Ochre River	Dauphin Lake	50°49'N 99°47'W	W. Franzin & S. Harbicht	7	DFO FWI	x
18/06/84	Ochre River	Dauphin Lake	50°56'N 99°49'W	"	1	"	x
19/06/84	Ochre River	Dauphin Lake	57°04'N 99°47'W	"	1	"	x
19/06/84	Ochre River	Dauphin Lake	50°56'N 99°48'W	"	3	"	x
20/06/84	Edwards River	Dauphin Lake	51°08'N 99°55'W	W. Franzin & S. Harbicht	2	DFO FWI	x
25/09/84	Scott Creek	Dauphin Lake	50°49'N 99°36'W	"	17	"	x
26/09/84	Ochre River	Dauphin Lake	50°54'N 99°49'W	"	16	"	x
18/05/86	Hansen Creek	Dauphin Lake	51°04'N 99°27'W	"	1	"	x

¹Royal Ontario Museum, Toronto, Ontario.²National Museum of Natural Sciences, National Museums of Canada, Ottawa, Ontario.³Freshwater Institute, Department of Fisheries and Oceans, Winnipeg, Manitoba.⁴Zoology Department, University of Manitoba, Winnipeg, Manitoba.⁵Moshenko (1972).⁶Kooyman and Hutchison (1979).⁷Gaboury (1985).⁸Gaboury (personal communication).

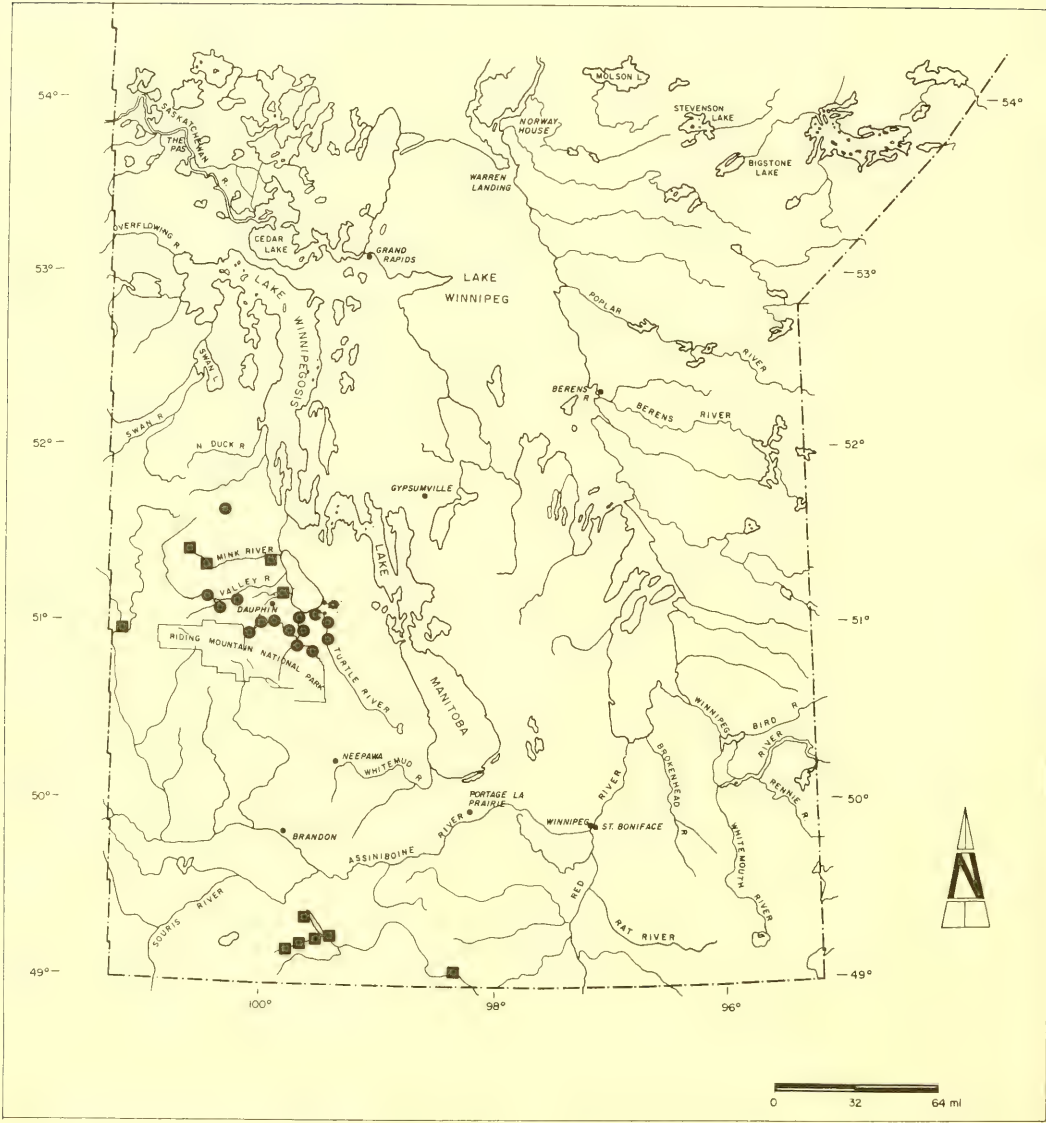


FIGURE 1. Distribution of *Hybognathus hankinsoni* in Manitoba.
■ previously published locations; ● new locations.

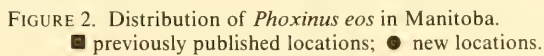


TABLE 2. Known distribution of *Phoxinus eos* in Manitoba. Collections above the line are previously published (Scott and Crossman 1979; Lee et al. 1980).

Date of collection (1900s)	Location	Drainage system	Geographic coordinates	Collector	No. of Specimens	Specimen storage location	Authors' verification
/07/50	Telford Pond	Winnipeg River	49° 50'N 95° 23'W	A. H. Kooyman	1	ROM ¹ 17389	
17/06/55	Rennie River	Winnipeg River	49° 51'N 95° 38'W	J. J. Keleher	—	ROM 18779	
04/08/64	Rennie River	Winnipeg River	49° 51'N 95° 38'W	F. R. & J. C. Cook	—	NMC ² 640602	
summer/76	Pine Creek	Lake Manitoba	50° 02'N 99° 01'W	M. Gaboury ⁶	2	not available	
summer/76	Pine Creek	Lake Manitoba	49° 54'N 99° 12'W	M. Gaboury	24	not available	
/05/73	Souris River	Souris River	49° 37'N 100° 49'W	D. G. Giles	1	ROM 36045	
summer 78	Brokenhead River	Lake Winnipeg	49° 38'N 96° 19'W	R. Tallman ⁷	5226	UMZ ³ (some)	x
summer 79	Brokenhead River	Lake Winnipeg	49° 38'N 96° 19'W	R. Tallman	2	UMZ	x
13/04/81	Tributary of Whitemud River	Lake Manitoba	50° 07'N 99° 19'W	W. N. Howard	2	ROM 37780	
22/06/82	Vermilion River	Dauphin Lake	51° 01'N 100° 10'W	W. Franzin & S. Harbicht	1	DFO ⁴ - FW1	x
unknown	Stream 2 mi. N of Caddy Lake Campground	Winnipeg River	49° 50'N 95° 15'W	G. E. Moodie	3	U of W ⁵	x
27/05/86	Rat River between PTH210 and PTH203	Red River	49° 13'N 96° 05'W	R. Cann, G. Worley & K. W. Stewart	277	UMZ	x

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³Zoology Department, University of Manitoba, Winnipeg, Manitoba.

⁴Freshwater Institute, Department of Fisheries and Oceans, 501 University Crescent, Winnipeg, Manitoba.

⁵University of Winnipeg, Winnipeg, Manitoba.

⁶M. Gaboury (personal communication).

⁷R. Tallman (1979).

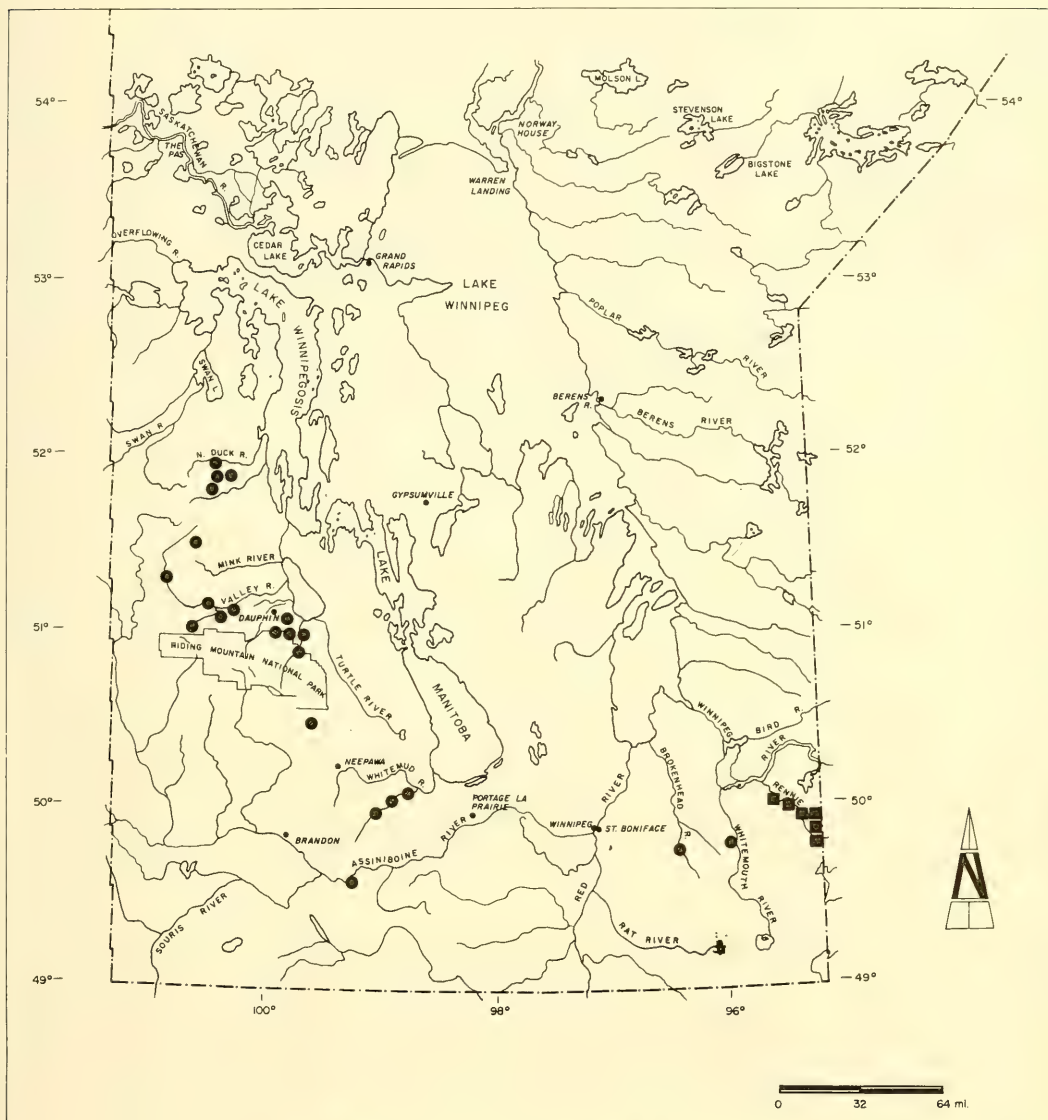


FIGURE 3. Distribution of *Phoxinus neogaeus* in Manitoba.
■ previously published locations; ● new locations.

TABLE 3. Known distribution of *Phoxinus neogaeus* in Manitoba. Collections above the line are previously published (Scott and Crossman 1979; Lee et al. 1980).

Date of collection (1900s)	Location	Drainage system	Geographic coordinates	Collector	No. of Specimens	Specimen storage location	Authors' verification
14/06/44	Brereton Lake	Winnipeg River	49° 54'N 95° 33'W	J. A. McLeod & R. Moir	5	ROM ¹ 14910	
/07/50	Telford Pond	Winnipeg River	49° 50'N 95° 23'W	A. H. Kooyman	1	ROM 17390	
17/07/55	Rennie River	Winnipeg River	49° 51'N 95° 38'W	J. J. Keleher	—	ROM 18808	
22/07/64	Lily Pond, 2.7 km west of Caddy Lake						
24/07/64	Caddy Lake	Winnipeg River	49° 49'N 95° 15'W	F. R. & J. C. Cook	—	NMC ² 640601	
23/07/64	Caddy Lake	Winnipeg River	49° 49'N 95° 15'W	" "	—	NMC 640393	
04/08/64	Rennie River	Winnipeg River	49° 49'N 95° 15'W	" "	—	NMC 640592	
		Winnipeg River	49° 51'N 95° 34'W	" "	—	NMC 640602	
11/06/74	McFadden Creek	Lake Manitoba	50° 29'N 99° 34'W	A. H. Kooyman & R. Hutchison ⁶	3	not available	
20/06/74	Ochre River	Dauphin Lake	50° 56'N 99° 49'W	A. H. Kooyman	4	"	
13/06/75	Pleasant Valley Creek	Dauphin Lake	51° 02'N 101° 05'W	W. N. Howard	2	ROM 37779	
summer/76	Pine Creek	Lake Manitoba	50° 02'N 99° 01'W	M. Gaboury ⁷	—	not available	
summer/76	Pine Creek	Lake Manitoba	50° 04'N 98° 57'W	" "	—	"	
summer/76	Pine Creek	Lake Manitoba	49° 54'N 99° 13'W	" "	—	"	
summer/76	Pine Creek	Lake Manitoba	50° 06'N 98° 56'W	" "	—	"	
summer/76	Sclater River	L. Winnepigosis	51° 56'N 100° 36'W	" "	—	"	
summer/76	Sclater River	L. Winnepigosis	51° 55'N 100° 39'W	" "	—	"	
12/06/79	Shanty Lake	L. Winnepigosis	51° 29'N 100° 43'W	G. A. Edwards	14	ROM 36378	
summer/78	Brokenhead River	Lake Winnipeg	49° 38'N 96° 19'W	R. Tallman ⁸	1086		
summer/79	Brokenhead River	Lake Winnipeg	49° 38'N 96° 19'W	" "	4	UMZ ³	x
21/05/80	Garland Creek	L. Winnepigosis	51° 39'N 100° 29'W	W. Franzin & S. Harbicht	5	DFO ⁴ FW1	x
11/06/80	Garland Creek	L. Winnepigosis	51° 39'N 100° 29'W	" "	1	"	x
04/07/80	Cowan Creek	L. Winnepigosis	52° 01'N 100° 39'W	" "	5	"	x
24/07/80	North Duck River	L. Winnepigosis	52° 01'N 100° 43'W	" "	1	"	x
29/06/82	Wilson River	Dauphin Lake	51° 07'N 100° 29'W	" "	2	"	x
29/06/82	Crawford Creek	Dauphin Lake	51° 01'N 99° 52'W	" "	2	"	x
-/07/82	Valley River	Dauphin Lake	51° 17'N 99° 55'W	M. Gaboury ⁹	2	not available	
-/07/82	Valley River	Dauphin Lake	51° 13'N 100° 20'W	" "	3	"	
summer/82	Silver Creek	Dauphin Lake	51° 12'N 100° 38'W	" "	592	"	
summer/82	Silver Creek	Dauphin Lake	51° 16'N 100° 51'W	" "	146	"	
summer/82	Pleasant Valley Creek	Dauphin Lake	51° 09'N 100° 49'W	" "	1030	UMZ (some)	x
11/08/82	Edwards Creek	Dauphin Lake	51° 07'N 100° 04'W	W. Franzin & S. Harbicht	1	DFO FW1	x
11/08/82	Ochre River	Dauphin Lake	50° 56'N 99° 49'W	" "	1	"	x
16/05/83	Ochre River	Dauphin Lake	50° 58'N 99° 47'W	" "	1	"	x

Continued

TABLE 3. *Concluded.*

Date of collection (1900s)	Location	Drainage system	Geographic coordinates	Collector	No. of Specimens	Specimen storage location	Authors' verification
16/05/83	Ochre River	Dauphin Lake	51°01'N 99°52'W	W. Franzin & S. Harbicht	1	" "	x
10/06/83	Ochre River	Dauphin Lake	51°01'N 99°52'W	" "	4	" "	x
20/06/83	Edwards Creek	Dauphin Lake	51°09'N 99°52'W	" "	4	" "	x
-/06/84	Whitemouth River	Lake Manitoba	49°45'N 95°57'W	K. W. Stewart & K. Leavesley		UMZ	
18/06/84	Ochre River	Dauphin Lake	50°56'N 99°49'W	W. Franzin & S. Harbicht	5	DFO FWI	x
19/06/84	Ochre River	Dauphin Lake	50°49'N 99°47'W	" "	1	" "	x
19/06/84	Ochre River	Dauphin Lake	50°56'N 99°48'W	" "	4	" "	x
17/04/84	Beaver Creek at Falcon Lake	Winnipeg River	49°41'N 95°18'W	K. W. Stewart & A. Shostak	(series)	UMZ	x
Unknown	Stream 2 mi. N of Caddy Lake						
28/07/84	Kiche Manitou Lake campground	Winnipeg River	49°50'N 95°15'W	G. E. Moodie		U of W ⁵	x
		Assiniboine R.	49°39'N 99°16'W	K. W. Stewart & K. Leavesley	8	UMZ	x
29/09/84	Brokenhead River	Lake Winnipeg	49°39'N 96°17'W	K. W. Stewart	33	UMZ	x
30/09/84	Kiche Manitou Lake	Assiniboine R.	49°39'N 99°16'W	" "	4	UMZ	x
27/05/86	Rat River between PTH210 and PTH203	Red River	49°13'N 96°05'W	R. Cann, G. Worley & K. W. Stewart	98	UMZ	x

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species in Canada (Lee et al. 1980), but they now better match limits in recently compiled maps for adjacent Saskatchewan (Atton and Merkowsky 1983).

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Yellow-billed Loon, *Gavia adamsii*, Breeding Chronology and Reproductive Success in Arctic Alaska

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North, Michael R., and Mark R. Ryan. 1988. Yellow-billed Loon, *Gavia adamsii*, breeding chronology and reproductive success in arctic Alaska. *Canadian Field-Naturalist* 102(3): 485-490.

The breeding ecology of Yellow-billed Loons (*Gavia adamsii*) was studied in 1983 and 1984 on the Colville River delta in arctic Alaska. Yellow-billed Loons arrived on the delta within four days after open water became available in river channels in late May. They stayed on rivers until open water leads formed along lakeshores. The first nests were found on 15 and 16 June, 1983, and 1984, respectively, but in 1984 the peak of nest initiation was delayed about one week because of late ice melt on the lakes. The first young hatched 11 July both years. Incubation length was 27 to 28 days. At least one egg hatched from 16 of 17 nests monitored both years. Productivity was 1.29 chicks/breeding pair in 1983 and 0.94 chicks/breeding pair in 1984.

Key Words: Yellow-billed Loons, *Gavia adamsii*, breeding chronology, reproductive success, Alaska.

The Yellow-billed Loon (*Gavia adamsii*) occurs sporadically throughout the arctic tundra of North America and Eurasia. In Alaska, Bailey (1948) found the species nesting irregularly along the arctic coast northward from Cape Prince of Wales. Yellow-billed Loons have been reported at a few inland locations in Alaska (Bailey 1948; Bee 1958; Irving 1960; Sage 1971; Derksen et al. 1979, 1981).

Yellow-billed Loons breed throughout much of mainland arctic Canada and the western high arctic islands but little is known of their abundance (Snyder 1957; Palmer 1962; Godfrey 1966). Bent (1919) reported Yellow-billed Loons to be numerous on Banks Island and he speculated that the species' main breeding grounds were on the Canadian arctic islands. The Yellow-billed Loon is also a common breeder in northeastern Siberia (Dement'ev and Gladkov 1968; Portenko 1981) and a rare breeder across the rest of arctic Eurasia to Finland (Dement'ev and Gladkov 1968).

Few ecological studies have been conducted on the Yellow-billed Loon because of the remoteness of its breeding range and the low densities at which the species typically occurs. Sjolander and Agren (1976) conducted an eight-week study of the reproductive behavior of renesting Yellow-billed Loons near Alaktak, Alaska. Sage (1971) studied two breeding pairs of Yellow-billed Loons in an area between the Colville and Canning rivers in Alaska. All other information on Yellow-billed Loon breeding biology comes from accounts of early expeditions to the Arctic (e.g. Dixon 1916; Bailey 1948; Sutton 1963) or from studies of habitats and other species (e.g. Smith 1973;

Bergman et al. 1977; Derksen et al. 1979, 1981). Data on basic aspects of Yellow-billed Loon breeding biology, such as breeding chronology, habitat selection, and reproductive success, are lacking.

As human-related activity increases in the Arctic, the potential threats to populations of already rare species such as Yellow-billed Loons increase substantially. The Colville River delta, one of two known breeding concentrations of Yellow-billed Loons in arctic Alaska, is an area of probable oil drilling activity (see North (1986) for details). In 1983, in cooperation with the U.S. Fish and Wildlife Service, we initiated a study of the breeding ecology of Yellow-billed Loons in the Colville River delta to provide basic information necessary to gauge the impact of oil resource development. In this paper we document the chronology of the Yellow-billed Loon breeding cycle and present data on reproductive success.

Study Area

The Colville River is the major river of arctic Alaska. It drains an area of 60 000 km² (Walker 1983) and forms a delta 260 km southeast of Point Barrow. The delta is a 575-km² area of dendritic river channels, fluvial deposits of various ages, low relief, and numerous thaw lakes at different stages of development. Lakes larger than 5 ha cover 16% of the delta's surface (Walker 1978). Wetlands on the delta range from ubiquitous, < 0.1-ha pools in polygon basins to a few tapped (Walker 1978, 1983) and untapped wetlands larger than 100 ha. Tapped wetlands are connected to river channels

through direct breaches or through a series of channels running from lake to lake and eventually into a river. Tapped lake water levels fluctuate with river level fluctuations. The first open water on the delta each spring occurred in river channels and tapped lake basins. We first observed melt-water in the river during the last week of May in both years.

Early U.S. Fish and Wildlife Service surveys found a large concentration of breeding Yellow-billed Loons in the Colville River delta (Derksen et al. 1981). The delta also supports breeding populations of Pacific Loons (*G. pacifica*), Red-throated Loons (*G. stellata*), Tundra Swans (*Cygnus columbianus*), Greater White-fronted Geese (*Anser albifrons*), Brant (*Branta bernicla*), and a variety of shorebirds (Scolopacidae, Charadriidae) and gulls (Laridae). Potential predators of loon eggs and chicks included Glaucous Gulls (*Larus hyperboreus*), Parasitic Jaegers (*Stercorarius parasiticus*), Long-tailed Jaegers (*S. longicaudus*), and Arctic Fox (*Alopex lagopus*), all of which were common on the delta. Common Ravens (*Corvus corax*), Snowy Owls (*Nyctea scandiaca*), and Red Foxes (*Vulpes vulpes*) were less common.

Methods

Field studies were conducted from 12 May to 15 August 1983 and from 16 May to 29 August 1984. Our camp was centrally located on the delta 10 km from the Beaufort Sea on the Tamayayak Channel. This location afforded us easy access to most of the delta.

We located most nests during time-budget observations of pairs and while walking shorelines during population surveys. We determined dates of nest initiation from observation of egg laying or by back-dating from date of hatching. We monitored nest fates during time-budget observations, population surveys, and regular nest visits.

We did not attempt to count eggs at nests in 1983 to minimize disturbance and the probability of egg predation. Eggs were counted only if the incubating adult was inadvertently flushed from the nest. During 1983, we observed that loons quickly returned to their nests after our brief visits, and in 1984 we determined clutch sizes for nearly all nests. Egg counts were made early in the nesting season. If one egg was present during the initial count, we rechecked the nest a few days later. We did not make additional egg counts from nests that had two eggs at the initial count.

Nests within 10 km of camp (by boat) were checked every one to three days from a week before the expected hatch date until hatch occurred.

Twelve loon pairs were visited frequently (> 10 visits over the two-year study). Six other pairs were visited occasionally (5–10 visits) and 14 pairs were rarely visited (1–4 visits). We did not flush the incubating adult if it was visible on the nest. Initial chick counts were made when we discovered that the young had hatched. Brood counts were obtained for 17 pairs between 6 and 12 August 1983, when chicks were two to four weeks old. In 1984, we made brood counts for 18 pairs from 2 to 6 August, when chicks were two to three weeks old, and again, for 17 pairs from 17 to 20 August, when chicks were four to five weeks old.

Results and Discussion

Breeding Chronology and Habitat Conditions

The first open water available to loons each year was in river channels. In 1983, local melt-water began accumulating in river channels 30 May. The first Pacific Loon was seen on 30 May and the first Yellow-billed Loon on 31 May. Small open-water leads began forming along lake margins on 1 June, but were too small for loons to utilize until 4 June. Yellow-billed Loons used rivers, tapped lakes, and probably leads in the Beaufort Sea exclusively until 4 June when we first observed them utilizing open water on their territorial lakes.

In 1984, melt-water from upstream began flowing in the Tamayayak Channel on 27 May. The first melt-water slowly flowed through 20–40 cm of snow in the channel basin because no local melting had occurred by then. A pair of unidentified loons was observed on 29 May, and J. Helmericks (personal communication) saw Yellow-billed Loons near his home on the delta in very late May, but we did not see Yellow-billed Loons until 2 June. The first Pacific and Red-throated loons were observed 7 June.

Narrow open-water leads began forming along lake margins on 4 June 1984, but the leads were too small to be utilized by loons until 11 June when Yellow-billed Loons were first observed on their territories. Open-water leads on a 229-ha lake adjacent to camp were too small to be utilized by loons until 14 June, 10 days later than in 1983. Delayed melting of lake ice in 1984 was probably due to 20 cm of snow on the ice that was not present in 1983. Three pairs of Yellow-billed Loons occupied territories on the large lake by our camp. One pair (presumably the same one) was often seen on the river by our camp while open-water leads were beginning to form. The pair frequently took off, flew low along the lake shoreline, and called tremolo (Sjolander and Agren 1976) as they flew. They would then circle back in a figure-8 pattern

TABLE 1. Incubation periods for three Yellow-billed Loon clutches on the Colville River delta, Alaska.

Pair Number	Year	First egg laid	Hatching date	Incubation period
201	1983	15 June	13 July	28 days
201	1984	23 June	20 July	27 days
249	1984	22 June	19 July	27 days

and land on the river at the place from which they took off. Another pair that nested on this lake frequently utilized an adjacent tapped lake while open-water leads were still narrow at the periphery of their territory.

Wetlands near the coast opened earlier than wetlands farther inland. On 11 June 1984, one lake had several decimeters of melt-water on the lake ice. A few days later the ice cake broke loose from the bottom and floated to the surface.

Rivers on the delta have contained open water as early as 22 May (T. Rothe, personal communication) as in 1981. Rothe also observed the first Yellow-billed Loons on that date. Arrival of Common, Arctic, Pacific, and Red-throated loons on their territories corresponds closely to the dates open water is first available (Munro 1945; Olson and Marshall 1952; Sjolander and Agren 1972; Vermeer 1973; McIntyre 1975; Sjolander 1978; Petersen 1979; Fox et al. 1980; Yonge 1981). Arrival of Yellow-billed Loons on the Colville River delta also occurred soon after open water first became available.

In 1983, we found nests (2) first on 15 June, and the first two broods on 11 July. Hatching was completed by 25 July. The incubation periods of three clutches were 27 to 28 days (Table 1). Incubation periods per egg for loons are difficult to estimate because eggs can be laid up to three days apart, and eggs in a single clutch can hatch up to 42 hours apart (Yonge 1981). Assuming an incubation period of 28 days in 1983, the first eggs were laid 13 June, 9 days after territories were re-occupied.

Nest initiation was delayed about one week in 1984. The first nest discovered was found on 16 June and hatched 11 July. If the incubation period was 27 days in 1984, the nest was initiated 14 June. No other nests were discovered until 22 June. The second brood was observed 15 July (probable nest initiation on 18 June). Hatching was completed by 28 July. Loons initiated nests about seven to eight days after returning to their territories in 1984. Pair

201 had a 28-day incubation period in 1983, but a 27-day period in 1984 (Table 1). In 1983, we monitored incubation at nest 201 from the date when the first egg was laid until it hatched. We did not observe the hatching of the second egg. In 1984, we knew the dates the first eggs were laid in nests 201 and 249, but only observed the date the second egg in each of these nests hatched.

Therefore, the length of time from first egg laid to first egg hatched for both 1984 nests was a maximum of 26 days. The reduced incubation period and the shortened interval between arrival on territories and nest initiation in 1984 may have been a response to the later availability of open water along lakeshores. Yonge (1981) found that Common Loons in northern Saskatchewan, in response to shorter ice-free periods, initiated nests sooner after arrival and had a shorter nesting period than Common Loons nesting farther south.

In both 1983 and 1984 the 229-ha lake by camp was the last lake on the delta to be completely ice free. The hatching of young of pairs that raised broods on the lake corresponded closely to the last ice melting. In 1983, one nest hatched 11 July and another hatched between 11 and 15 July. The last ice disappeared 13 July. In 1984, one nest hatched 15 July and another hatched between 15 and 17 July. The last ice disappeared 16 July. The relationship between the last ice melting and hatch is probably coincidental, because several other pairs hatched young up to 12 days after ice disappeared from their lakes. If hatch occurred long before ice melt was complete, however, adults may have had difficulty obtaining enough food for their young, and, at the same time, protecting them (North 1986).

Reproductive Success

We found 39 nests in 1983 and 1984 that we believe belonged to 23 Yellow-billed Loon pairs. No loons were marked; therefore, no proof exists that the same individuals occupied a given territory both in 1983 and in 1984. We believe that, on territories occupied both years, at least one member of each pair was present in both years. This belief is based on consistent locations of Yellow-billed and Pacific loon territories both years, immediate occupation of territories after open-water leads formed, maintenance of territories by non-nesting pairs and failed breeders, and re-utilization of all but one 1983 nest site in 1984. Territorial affinity has been documented in banded Arctic Loons (Sjolander 1978) and Common Loons (McIntyre 1974). Because all loon species exhibit similar behavioral patterns (Sjolander and Agren 1976), territorial affinity in

TABLE 2. Reproductive success of loons in North America.

Location and reference	Species	Year	Percent Success		Chicks per breeding pair (N)
			Nest (N) ^a	Egg (N)	
Alaska	<i>Gavia adamsii</i>	1983	94 (17)		1.29 (17)
this study		1984	94 (17)		0.94 (17)
Minnesota	<i>G. immer</i>	1950	39 (41)	49 (63)	0.50 (42)
Olson and Marshall (1952)					
Alberta	<i>G. immer</i>	1972		70 (37)	
Vermeer (1973)					
Minnesota	<i>G. immer</i>	1970-		41 (90)	0.77 (25)
McIntyre (1975)		1974			
New Hampshire	<i>G. immer</i>	1976-	37 (78)		0.63 (60)
Sutcliffe (1978)		1977			
Saskatchewan	<i>G. immer</i>	1973			0.68 (70)
Fox et al. (1980)		1974			0.78 (74)
Minnesota	<i>G. immer</i>	1975	39 (79)	42 (119)	0.63 (64)
Titus and VanDruff (1981)		1976	41 (61)	46 (83)	0.65 (48)
Alaska	<i>G. pacifica</i> ^b	1974	5 (19)		0.05 (19)
Petersen (1976, 1979)		1975	32 (59)		0.17 (59)
Alaska	<i>G. pacifica</i> ^b	1971	28 (14)		
Bergman and Derksen (1977)		1972	92 (12)		
		1973	53 (15)		
		1974	40 (7)		
		1975	56 (9)		
Alaska	<i>G. stellata</i>	1971	33 (6)		
Bergman and Derksen (1977)		1972	78 (9)		
		1973	45 (9)		

^aSample sizes.

^bPacific Loons were considered a subspecies of Arctic Loons during these studies.

Yellow-billed Loons is probably similar to that in Common and Arctic loons.

Yellow-billed Loon mean clutch size was 1.88 ± 0.14 ($n = 8$) in 1983 and 1.89 ± 0.07 ($n = 19$) in 1984. Yonge (1981) believed that different mean clutch sizes reported in Common Loon studies reflected different rates of egg loss. Pacific and Red-throated loons on the Colville River delta had mean clutch sizes of 1.90 ± 0.07 ($n = 20$) and 1.86 ± 0.09 ($n = 14$), respectively.

Sixteen of 17 nests (94.1%) hatched successfully in each year, a very high nest success rate for loons (Table 2). The one nest failure in 1983 was probably caused by shifting ice. In 1984 one nest, located on an island was probably destroyed by an avian predator. The high nest success we observed may have been the result of little human disturbance, few mammalian predators, and lack of predation by larids. Bergman and Derksen (1977) found Pacific Loon nest success varied from 28 to 92 percent and Red-throated Loon nest success varied from 33 to 78 percent during a five-year study at Storkersen Point, Alaska.

Yellow-billed Loon chick survival was high on the Colville River delta. Productivity was 1.3

chicks per breeding pair in 1983 (Table 3). During brood counts made 2-6 and 17-20 August 1984 we found 1.1 and 0.9 chicks per breeding pair, respectively. Two chicks disappeared between brood counts in 1984, one from a two-chick brood and the other a single chick. Although we did not remain in the study area through fledging, our estimates of chick survival to four weeks probably accurately reflect fledging rates. Most mortality of loon chicks occurs within two weeks after hatching, and chicks surviving beyond this period have a good chance of fledging (Olson and Marshall 1952; Petersen 1976; Sutcliffe 1978; Yonge 1981). Titus and VanDruff (1981) considered the number of Common Loon chicks alive after two weeks to be the number fledged, but McIntyre (1983) considered only the number alive after four weeks to be the number fledged.

Yellow-billed Loon reproductive success could be limited by low egg/nest success or by low chick survival. Olson and Marshall (1952) reported that egg loss was the major limiting factor of Common Loon reproduction. They observed 35 of 51 nests (61%) fail and 32 of 63 eggs (51%) not hatch. Fox et al. (1980) had 261 of 424 (61.6%) Common Loon eggs fail.

TABLE 3. Yellow-billed Loon chick survival on the Colville River delta, Alaska, 1983 and 1984.

	6-12 August 1983	2-6 August 1984	17-20 August 1984
Age of chicks (weeks)	2-4	2-3	4-5
No. of broods counted	17	18	17 ^a
No. of 1-chick broods	6	8	8
No. of 2-chick broods	8	6	4
Total no. of chicks	22	20	16
Chicks/breeding pair ^b	1.29	1.11	0.94
Chicks/pair hatching young ^c	1.38	1.18	1.00

^aOne pair not revisited.^bBased on number of broods counted.^cOne pair was unsuccessful in each year.

The reproductive success of Yellow-billed Loons on the Colville River delta was greater than that reported for loons elsewhere (Table 2). Fox et al. (1980) concluded that oligotrophic lakes fledged twice as many Common Loon young as eutrophic lakes. They cited increased chick foraging efficiency (because of water clarity) and less exposure to Northern Pike (*Esox lucius*) as factors contributing to high chick survival.

Whereas studies of other loon species found that productivity for all breeding pairs was low (Table 2), some found chick survival to be high for successful pairs. Fox et al. (1980) found that young fledged per pair hatching young was 1.5 in both 1973 and 1974. Sutcliffe (1978) reported 1.3 young fledged per successful pair. McIntyre (1975) reported that brood size averaged 1.4 chicks per successful pair. The number of Yellow-billed Loon chicks per pair hatching young (i.e. chick survival) on the delta (Table 3) was similar to that reported for Common Loons. Therefore, high chick production on the Colville River delta, relative to loons in other areas, seems to be the result of an unusually low ratio of egg loss and not the result of unusually high chick survival.

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New Distributional Records of Marine Fishes off Washington, British Columbia and Alaska

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Peden, Alex E., and Glen S. Jamieson. 1988. New distributional records of marine fishes off Washington, British Columbia and Alaska. *Canadian Field-Naturalist* 102(3): 491-494.

Dasyatis violacea (Dasyatidae), *Cyclothone pallida* (Gonostomatidae), *Paralepis atlantica* (Paralepididae), *Scopelogadus mizolepis bispinosus* (Melamphaidae), *Taranetzella lyoderma* (Zoarcidae) and *Xiphias gladius* (Xiphiidae) are reported as new to, or confirmed within, Canada's 200 mile fishery zone in the eastern Pacific Ocean. First records of *Stellerina xyosterna* and *Xeneretmus leiops* (Agonidae) are reported for Alaska. Second records of *Taractes asper* (Bramidae) and *Seriola lalandi dorsalis* (Carangidae) are reported. *Luvarus imperialis* (Luvaridae) is reported just outside the southwestern corner of the Canadian fishery zone.

Key Words: North Pacific, British Columbia, Agonidae, Bramidae, Carangidae, Dasyatidae Gonostomatidae, Luvaridae, Melamphaidae, Paralepididae, Xiphiidae, Zoarcidae.

Peden (1986) summarized a number of new occurrences of marine fish species from western Canadian waters, and adopted the 200 mile (322 km) fishery zone recognized by Jean et al. (1982) as the area for documenting Canadian marine fauna. Sightings of other species previously unknown to the region continue to be made, particularly through the flying squid research program in the northeastern Pacific Ocean (eg. Robinson and Jamieson 1984; Sloan 1984). Here we report new records of species for Canadian waters, and verify others seldom reported for the area or which represent significant extensions of their known geographic range.

DASYATIDAE

Dasyatis violacea (Bonaparte) Pelagic Stingray

Clemens and Wilby (1960) discussed the identity of stingrays taken in 1928 off Kyoquot, B.C., but the lack of museum specimens made it impossible to identify the species. Hart (1973) suggested that either *Dasyatis dipterura* (Jordan) or *D. violacea* could have been the species involved.

We now have a Canadian specimen of *Dasyatis violacea* taken by the Japanese fishing vessel *Tomi Maru* #88 on 26 August 1985 at 49°45'N latitude, 132°46'W longitude (about 225 nautical miles west of Nootka Island, B.C.). It is catalogued at the Royal British Columbia Museum (formerly the British Columbia Provincial Museum) fish collection as BCPM 985-485.

Known as the Pelagic Stingray, its place of capture on the high seas supports this identification, as does its rounded anterior profile and

purplish-grey coloured ventral surface (see Miller and Lea 1972). The dorsal spine was missing at the time of our examination. The specimen was preserved in a distorted position with its total length about 980 mm; snout to end of pectoral fin, 320 mm; and snout to end of pelvic fin, 335 mm.

Even though our record suggests that *D. dipterura* might not be the species to recognize off western Canadian waters, the 1928 records near Kyoquot were caught on salmon lures and presumably in much shallower water. Therefore, the identity of such a record in a different inshore water mass should still be considered in doubt.

GONOSTOMATIDAE

Cyclothone pallida Brauer Tan Bristlemouth

Northern records of *Cyclothone pallida* were discussed by Peden et al. (1985) and Peden and Hughes (1986), with specimens recorded as far north as Station Papa (50°N, 145°W) or Oregon (Pearcy 1972). We now have a Canadian specimen, 58.8 mm standard length (=SL) and catalogued as BCPM 986-91. It was taken southwest of La Perouse Bank, 18 March 1986, by Philip Lambert aboard the CSS *Endeavor* at 48°08.1'N, 126°36.9'W, in 0 to 650 m depths, and represents the first verifiable record of the species within the 200-mile Canadian fishery zone.

The VAV series of photophores between anal and pelvic fins are five in number and evenly spaced, thus differentiating the species from its sympatric congener *C. pseudopallida* (Mukhacheva 1964). Counts: dorsal fin rays 14, anal rays 18, gill rakers 13 + 2 + 6, branchiostegal photophores 10, IV

photophores (preceeding pelvic fins) 13, AC photophores (above anal fin base) 15.

PARALEPIDIDAE

Paralepis atlantica Kroyer **Duckbill Barracudina**

Peden (1980) recorded *Paralepis atlantica* from weathership station Papa (50°N, 145°W) and noted published records off Washington State, but no records of specimens within the Canadian fishery zone are published. There is a specimen in the fish collection of the University of British Columbia without accurate locality data.

We now have a documentable Canadian specimen (410 mm SL) donated to us by Dick Nagtegaal of the Pacific Biological Station at Nanaimo, B.C. (BCPM 985-484). It was taken in a trawl haul by the M/V *Howe Bay* between 48° 30.33'N, 126° 10.62'W and 48° 24.95'N, 126° 09.35'W at Deep Big Bank north of Cape Flattery, in 0 to 344 m depths on 16 September 1985. Being from a minimum of at least 20 nautical miles inside the southern boundary of Canadian waters, it provides the first authentic record of a Canadian specimen. The specimen's 10 dorsal fin rays, 23 anal rays, 16 short pectoral rays, 66 vertebrae (including urostyle), 59 lateral line pores, deciduous scales and pattern of toothed gill rakers readily confirmed the species as *P. atlantica* (Rofen 1966).

MELAMPHAIDAE

Scopelogadus mizolepis bispinosus (Gilbert)

Soft Melamphid

Berry and Perkins (1966) indicate that *Scopelogadus mizolepis bispinosus* is abundant off California, although Percy's tabulation (1972) of oceanic organisms does not list the species off Oregon. Ebeling (1962) and Ebeling and Weed (1973) reviewed the species of *Scopelogadus* and indicate that *S. m. bispinosus* is restricted to the eastern tropical Pacific Ocean.

On 17 March 1986 Philip Lambert obtained a 49 mm S.L. specimen (BCPM 986-90) southwest of La Perouse Bank (48°08.1'N, 126°36.9'W) in 0 to 675 m depths. This is the only known specimen taken off western Canada. The large scale pockets (indicating about 15 or fewer deciduous lateral scales), combination of fin ray counts (dorsal II,11; anal I,8; pectoral 13; pelvic I,8) and absence of a supramaxillary bone distinguish our specimen from other melamphid species.

BRAMIDAE

Taractes asper Lowe

Rough Pomfret

Peden and Ostermann (1981) reported on a specimen of *Taractes asper* taken off the Queen Charlotte Islands, and noted published records from California to Japan and Alaska. We have now

obtained nine adults of this poorly known species from the following three localities (the first being the second known museum specimen from Canadian waters):

BCPM 985-478 (1; 307 mm SL), from 47°18'N, 128°12'W; gillnet, M/V *Tomi Maru* #88, 9 July 1985,

BCPM 985-480 (1; 392 mm SL), from 46°44'N, 130°58'W; M/V *Tomi Maru* #88, 13 July 1985,

BCPM 985-479 (7; 291 to 336 mm SL), from 46°36'N, 130°54'W, M/V *Tomi Maru* #88, 15 July 1985.

Counts: principal dorsal rays 26 to 31 (mean 28.3), principal anal rays 20–23 (mean 21.7), pectoral rays 16 to 17, and scales in lateral series 44 to 47 (mean 45.6).

CARANGIDAE

Seriola lalandi dorsalis (Gill)

Yellowtail

Nagtegaal and Farlinger (1981) reported the only record of *Seriola* from British Columbia and extended its known geographic range as far as 54°35'N. We now have another specimen (BCPM 983-1729, 630 mm SL) from within the Canadian fishery zone. It was listed by Sloan (1984: 18) and captured in gill nets by the M/V *Tomi Maru* #88 on 5 August 1983 at 47°57'N, 130°50'W. We also have a specimen (BCPM 985-487, 530 mm SL) from just outside Canadian waters caught by the M/V *Tomi Maru* #88 on 13 July 1985 at 46°44'N, 130°58'W.

Seriola lalandi may be a regular summertime visitor to offshore Canadian waters, since Bernard (1980, 1981) records them in the following catch records incidental to the Japanese high seas squid fishery. Such records have not been commonly acknowledged by ichthyologists: 1 kg caught by M/V *Kohoku Maru* #18 on 3 October 1979 at 49°26.2'N, 128°53.6'W (Bernard 1980); 2 kg caught by M/V *Tenyu Maru* #37 on 28 September 1979 at 47°49.9'N, 128°27.9'W (Bernard 1980); 6 kg caught by M/V *Tenyu Maru* #37 on 29 September 1979 at 48°24.4'N, 126°2.6'W (Bernard 1980); 1 kg caught by M/V *Tomi Maru* #88 on 15 August 1980 at 48°25.4'N, 126°38'W (Bernard 1981); 24 kg caught by M/V *Tomi Maru* #88 on 23 August 1980 at 49°38.7'N, 132°52.0'W (Bernard 1981); 9 kg caught by M/V *Tomi Maru* #88 on 24 August 1980 at 49°24.5'N, 132°43.4'W (Bernard 1981).

LUVARIDAE

Luvarus imperialis Rafinesque

Luvar

Miller and Lea (1972) and Eschmeyer et al. (1983) record the distribution of *Luvarus imperialis* reaching northward to about Newport, Oregon. We obtained two specimens of about 705 and 660 mm SL (BCPM 985-482) taken by the M/V *Tomi Maru* #88 on 15 July 1985 at 46°36'N, 130°54'W. Another

two, about 615 and 680 mm SL (BCPM 985-488), were taken by the same vessel on 14 July 1985 at 46°22'N, 131°09'W.

One of the collections taken west of Washington State was from about 37 nautical miles west of the southwestern boundary of the Canadian fishery zone near Cobb Seamount and suggests the species probably strays into Canadian waters.

Although the species is readily identifiable by its unique appearance (small mouth, highly developed nape, spinous rays only in dorsal and anal fins, lunate caudal fin and caudal keel (Miller and Lea 1972), Bolin (1940) notes major morphometric changes, with the anterior rays of both the dorsal and anal fins being overgrown by tissue, and pelvic rays being reduced in adults to a single plate-like scute. Our specimens have 11 to 14 exposed spinous dorsal rays, 14 or 15 exposed spinous anal rays, 17 or 18 pectoral rays, and one specimen has a pelvic scute (this scute damaged or lost on other specimens). There are 19 to 21 vertebrae (including urostyle).

XIPHIIDAE

Xiphias gladius Linnaeus

Swordfish

The Swordfish, *Xiphias gladius*, was reported off Oregon (Miller and Lea 1972) and a large individual taken off Washington is being reported elsewhere (Douglas Nelson, personal communication). We also received the remains of yet another specimen representing the first Canadian specimen. It was taken in the extreme southwestern extension of the Canadian fishery zone, but similar to the Washington specimen, it was partly eaten by the ship's crew before being examined by researchers. Of the 50 kg estimated weight, the sword and the caudal fin (along with the diagnostic single keel of the caudal peduncle) were preserved and catalogued (BCPM 983-1730). It was retrieved by N. A. Sloan from the M/V *Tomi Maru* #88 on 8 August 1983 at 47° 6'N, 131°03'W and listed by Sloan (1984).

AGONIDAE

Stellerina xyosterna (Jordan and Gilbert)

Pricklebreast Poacher

BarracloUGH and Peden (1977) recorded *Stellerina xyosterna* as far north as the Queen Charlotte Islands. Examination of Alaskan collections held as voucher specimens for the U.S. Bureau of Land Management at the California Academy of Sciences revealed a specimen, 79 mm SL, taken off Icy Bay, Alaska, at 59°52'54"N, 141°51'18"W. It was taken in an otter trawl by the R/V *Miller Freeman* on 23 November 1979 in 27 to

29 m depths and represents the first record for the species in Alaskan waters as well as a significant (400 nautical mile) extension of the known northern range.

The specimen is catalogued as CAS 47039. Counts are dorsal rays VII, 6; anal rays 9; pectoral rays 19; dorsolateral plates 23; mid-dorsal plates 13; supralateral plates 31; lateral line pores 31; infralateral plates 37; ventrolateral plates 20; midventral plates 14.

Xeneretmus leiops Gilbert

Smootheye Poacher

BarracloUGH and Peden (1977) recorded the first records for British Columbia as far north as 48°48'N latitude. We now have a specimen (NMC 66-268; 206 mm SL) taken off Forrester Island, Alaska, at 54°42'N, 134°W by W. Van Vleit while aboard the R/V *G. B. Reed* on 2 September 1966. It represents a 450 nautical mile northern extension of the known geographic range and the first published record for Alaskan waters.

The specimen is readily identified by the darkened distal margin of the spinous dorsal fin, with dark pigment extending halfway down the first two spinous dorsal rays. Counts are dorsal rays VI, 6; anal rays 5; pectoral rays 14; dorsolateral plates 23; middorsal plates 18; supralateral plates 40 + 1; lateral line pores 43; infralateral plates 40 + 1; ventrolateral plates 21; midventral plates 43.

ZOARCIDAE

Taranetzella lyoderma Andriashev

Ghostly Eelpout

Taranetzella lyoderma was described from the Bering Sea (Andriashev 1952). Many more specimens are known from off Oregon and Washington. We have examined OSUO 1896 and one from OSUO BMT 288, although many others are held at the California Academy of Sciences. Through the courtesy of David Stein, School of Oceanography, Oregon State University, we examined two specimens (OSUO DWD B.M.T.-2), 110 and 145 mm SL, taken west of Vancouver Island at 48° 18.9'N, 127°01'W in depths of 2520 m. These are the only specimens known from Canadian waters.

The specimens are identifiable as *T. lyoderma* by the presence of pelvic fins, gill openings not extending forward under jaw, strong jaw teeth, loose "liparid-like" skin, wide interorbital space, and weak development of scales restricted to posterior portion of body (Andriashev 1952). Counts: dorsal rays 86 to 91; anal rays 72 to 79; pectoral rays 15; vertebrae 19 + 71 to 78 = 90 to 97.

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The Status of Trumpeter Swans, *Cygnus buccinator*, in Western Canada, 1985

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McKelvey, Richard W., Kevin J. McCormick, and Leonard J. Shandruk. 1988. The status of Trumpeter Swans, *Cygnus buccinator*, in western Canada, 1985. *Canadian Field-Naturalist* 102(3): 495-499.

A survey of naturally occurring Trumpeter Swans, *Cygnus buccinator*, conducted in the Yukon and Northwest territories, British Columbia, Alberta and Saskatchewan between 27 July and 20 September 1985 indicates an expanding population in western Canada. A total of 456 adult-plumaged birds and 191 cygnets was recorded. Comparisons with previous survey data showed that the Yukon population had declined since 1981, but that the British Columbia and Alberta populations had increased. The Northwest Territories population was not previously documented, although Trumpeter Swans had been recorded in Nahanni National Park Reserve. The Saskatchewan population remains precariously low.

Key Words: Trumpeter Swan, *Cygnus buccinator*, Yukon Territory, Northwest Territories, British Columbia, Alberta, Saskatchewan, breeding status.

The Trumpeter Swan, *Cygnus buccinator*, once bred from near the tree-line in northern Canada and Alaska to the central United States, and from the west coast to east of the Great Lakes (Banko 1960). Today the species is confined to parts of Alaska, northwestern Canada, adjacent areas of Idaho, Montana and Wyoming ("the tri-state area"), and several other small areas where it has been reintroduced. The world population numbered about 10 000 birds in two major groups in 1984 (North American Trumpeter Swan management plan 1984; manuscript available from United States Fish and Wildlife Service or Canadian Wildlife Service).

The Pacific coast population, about 8000 birds, breeds in Alaska and winters primarily on the coasts of British Columbia and Washington. Intensive surveys of the breeding grounds at approximately five-year intervals have been made fairly systematically since the mid 1960s (King and Conant 1981). The smaller Rocky Mountain population breeds in the Yukon Territory, Northwest Territories, British Columbia, Alberta and Saskatchewan. It winters in the tri-state area with a non-migratory group of swans. Surveys on the breeding grounds have not been as systematic as those of the Pacific coast population. Status of swans breeding near Grande Prairie, Alberta, and in the tri-state area has been determined more or less annually. The status of swans in the Yukon Territory (McKelvey et al. 1983), Northwest Territories (K. J. McCormick and L. J. Shandruk. 1986. A survey of Trumpeter Swans and their

habitat in southern Mackenzie District, Northwest Territories. Canadian Wildlife Service, Western and Northern Region Habitat Management Section Technical Report No. 86-53. 4 pp.) and northeastern British Columbia (McKelvey 1986) has only recently been determined.

In 1985 the first comprehensive survey of Trumpeter Swan breeding habitat in western Canada was planned in order to coincide with the survey in Alaska. Because the Committee on the Status of Endangered Wildlife in Canada (COSEWIC) classified the Trumpeter Swan as rare (Mackay 1978), this survey should form the baseline for future assessments of its status. Information is presented on the general areas surveyed and the numbers of birds seen. Changes from previous surveys are discussed and the potential for population growth is assessed.

Study Areas

We surveyed most areas known to have swan populations and relied on observations of others for data on small, isolated groups. The major areas covered are shown in Figure 1. Habitats in the Yukon (McKelvey et al. 1983) and Northwest territories (McCormick and Shandruk (see above)) are similar, being generally mountainous boreal forest with key habitats confined to wetland complexes on valley bottoms or to small lakes and associated tributaries within the forest. Most habitat is below 1100 m (3500 ft).

Habitat near Fort Nelson, British Columbia, in the foothills east of the Rocky Mountains is similar

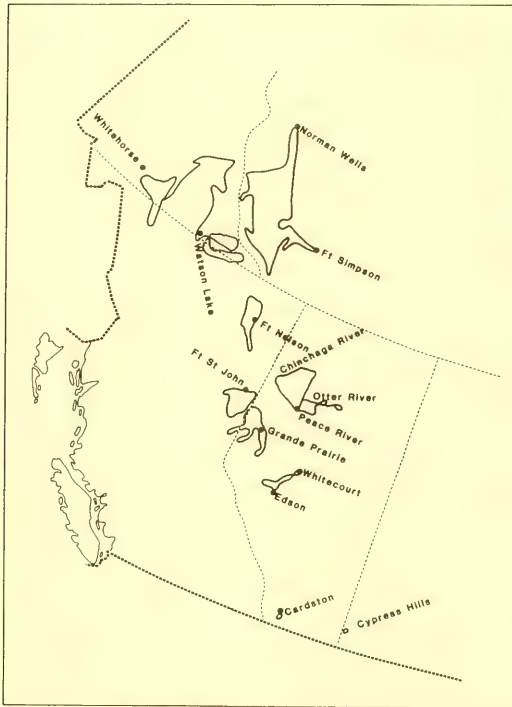


FIGURE 1. General location of survey routes used for the 1985 Trumpeter Swan survey in western Canada.

in nature to that in the Yukon Territory and the Northwest Territories, except that it is less mountainous. Habitats on the muskeg of the Fort Nelson lowlands are usually small lake complexes on slightly drier areas rather than the more open boggy regions. Elevations are low, usually not exceeding 600 m (2000 ft).

Habitat near Fort St. John, British Columbia, and Grande Prairie, Alberta, is on relatively flat to rolling terrain (the Alberta Plateau; cf. Holland 1964) dominated by mixed-wood forests or by farmland. Wetlands used by swans are small- to medium-sized lakes (< 50 ha), generally with well-developed emergent plant communities. Elevations do not generally exceed 900 m (3000 ft). Habitat elsewhere in Alberta is either mixed-wood boreal forest (northern Alberta) or aspen parkland (southern Alberta). The Cypress Hills area of Saskatchewan is an uplift area vegetated by mixed-wood boreal forest grading into mixed-grass prairie. The elevation is less than 900 m (3000 ft).

Methods

Surveys were conducted over as many known or suspected Trumpeter Swan habitats as possible

between 27 July and 20 September 1985. The general areas surveyed, the survey dates, and the survey participants are shown in Table 1. Actual survey routes are contained in manuscript reports available from the authors (Yukon Territory and British Columbia — RWM; Northwest Territories — KJM; Alberta and Saskatchewan — LJS). Logistics precluded simultaneous surveys over the whole range. Surveys were late enough in the season that all nesting had been completed but any migration had not begun.

All surveys were conducted from single-engine, high-wing aircraft flown at altitudes between 150 m and 300 m above ground level at cruising speeds of 100 knots. Flying heights and speeds were lowered when necessary to facilitate identifications and counts. Predetermined routes were followed from 1 : 250 000-scale topographic maps. The location of each sighting was recorded directly on the survey maps. Tape recorders were used to record incidental observations, including habitats.

Other sources consulted for swan sightings, in areas we did not survey, included waterfowl reconnaissance surveys in southwest Yukon Territory; habitat reconnaissance surveys in northeastern British Columbia; casual observations by conservation officers and biologists in British Columbia, Alberta and Saskatchewan, and United States Fish and Wildlife Service pilot-biologists flying through British Columbia and Yukon Territory; and habitat surveys in the Cypress Hills area of Saskatchewan.

Results and Discussion

A total of 458 swans in adult plumage and 191 cygnets was recorded in the 1985 survey (Table 1). The average brood size was 3.2 young per brood, with an overall productivity (cygnets/total swans) of 29.4%. Productivity in Yukon Territory was less than half of that elsewhere, and the brood size there was also small. Alberta swans showed the highest productivity and brood size, although they were similar to those in the Northwest Territories and British Columbia. The brood size in British Columbia was intermediate compared to those in Yukon Territory and Alberta, and that in the Northwest Territories was only slightly lower than in Alberta. One breeding pair in Saskatchewan produced two cygnets.

Changes from previous surveys

The swan population in southeastern Yukon Territory apparently declined over the past five years. In 1980 the population in the Toobally Lakes area of Yukon Territory was 66 adult birds

TABLE 1. Number of swans seen by survey area on the 1985 Trumpeter Swan survey in western Canada, with dates and observers.

Location	Count				
	Birds in flocks	Singles	Pairs	Broods	Cygnets
Yukon Territory (27-29 July; RM) ¹					
Teslin Lake		3	1		
Ross River	4	3	7	3	8
Toobally Lakes		6	20	4	10
Other areas	23	3	6	1	2
Northwest Territories (5-8 August; KM, LS)					
Nahanni Butte area	11	6	17	7	24
British Columbia (3-5 August; RM)					
Fort Nelson			8	3	4
Fort St. John	8	3	16	7	23
Other areas		2	7	2	6
Alberta					
Cardston (29 August; LS)			3		
Edson (6 September; LS)		1	7	3	8
Grande Prairie (10-11 September; KM, LS)	82	3	51	26	98
Otter Lake (17 September; LS)	4		2	2	3
Chinchaga River (20 September; LS)			1	1	3
Saskatchewan ²					
Cypress Hills	2		1	1	2
Total	134	30	147	60	191

¹KM = K. McCormick, RM = R. McKelvey, LS = L. Shandruk.²Data from M. Killaby, Saskatchewan Department of Natural Resources.

with 19 cygnets, and in 1981 it was 68 adults with 26 cygnets (McKelvey et al. 1983). In 1985 the same area had only 46 adults and 10 cygnets. Several factors may have contributed to the decline. A large (30 000 ha) hot fire swept through the area in 1982. This fire may have caused direct mortality, from which the population has not yet recovered, or it could have displaced part of the population to other nearby areas including the Northwest Territories. Another possible cause of the decline could be recent mortality in the tri-state wintering area. Winter conditions are severe in that area; at least 50 swans died there during the winter of 1984-85 (R. Gale, Montana Cooperative Wildlife Research Unit, personal communication).

Trumpeter Swans have been known to breed in the Nahanni National Park Reserve since at least

1976 (Scotter et al. 1985). An intensive survey within and adjacent to the Park Reserve in 1984 revealed 18 adult-plumaged birds, including one pair with five cygnets and two pairs incubating five and six eggs, respectively (McCormick 1986). No intensive surveys were conducted outside the Park Reserve before 1985, although swans were known to be in the area. It seems likely that the appearance of that population is a recent phenomenon. Extensive surveys were made in the southern Mackenzie District during the 1970s before the establishment of Nahanni National Park Reserve, and it is unlikely that swans would have gone unnoticed if they had been present then. This new population probably represents pioneering from surrounding areas, including the local population in Nahanni National Park Reserve, or a possible displacement of birds

from Yukon Territory. Trumpeter Swans are not known to pioneer new areas quickly, so local expansion or displacement seems more likely.

Swans breeding near Fort Nelson, British Columbia, were first surveyed in 1981 (McKelvey, *unpublished*). A slightly smaller area was surveyed in 1981 than in 1985 (McKelvey 1986). On the areas surveyed in both years, fewer pairs were noted in 1985, but more young birds were seen. No broods were found in 1981, whereas in 1985 three broods with a total of four young were located. Parts of the Fort St. John flock in the Dawson Creek area have been surveyed over the years in conjunction with the Grande Prairie flock. Swan numbers in that area have generally increased in common with the rest of the Grande Prairie flock. Another component of the Fort St. John flock in the vicinity of Boudreau Lake ($56^{\circ}10'N$, $121^{\circ}30'W$) was first surveyed and documented in 1981 (R. W. McKelvey, 1981. Surveys of waterbirds in the Boudreau Lakes area, northeastern British Columbia. Unpublished report. Canadian Wildlife Service, Delta. 25 pp.). At that time three pairs and one group of four birds were seen, whereas in 1985 four pairs with 11 cygnets, and one lone bird were found.

Other areas in British Columbia where Trumpeter Swans were reported in 1985 included the Alsek River near Atlin, and Old Man Lake ($54^{\circ}25'N$, $125^{\circ}24'W$) near Smithers. The Alsek River had two pairs and one lone adult with a brood of four. Swans were seen on that river in 1978 (B. Conant, United States Fish and Wildlife Service, personal communication) but 1985 was the first recorded incidence of breeding. Swans breeding near Smithers, British Columbia, were first noted in 1978 (N. Trenholm, Ducks Unlimited Canada, personal communication), when two young were produced. Their status since is uncertain. In 1985 a pair was seen in the spring but it was apparently unsuccessful in producing young.

Swan surveys have been conducted annually since 1959 in the Grande Prairie area of Alberta, but are relatively recent in other areas where swans are considered to be pioneering. Since then the Grande Prairie flock has increased from 127 to 285 birds (adults and cygnets). In 1984, 343 swans were seen, considerably more than in 1985. The decrease in 1985 is believed to have resulted from the die-off in the tri-state wintering area. Productivity remained good in 1985 and the upward trend in the population is expected to continue.

Alberta areas in which pioneering of swans is occurring include the Edson/Whitecourt area, the Otter and Russell lakes area 100 km northeast of Peace River, the Chinchaga River northwest of

Manning, and the Pincher Creek-Cardston area near Waterton Lakes National Park. None of these areas showed major changes from surveys in the past.

Surveys have been conducted in Saskatchewan since 1972, when three breeding pairs produced 10 cygnets. Since then the population has declined to one breeding pair, which produces two or three cygnets annually (M. Killaby, Saskatchewan Department of Renewable Resources; personal communication).

The future

The population of Trumpeter Swans nesting under natural conditions in western Canada appears to be reasonably stable and productive. Where comparable data existed, the population has generally shown an increase since 1980, except in Yukon Territory. The Canadian population accounts for only about 6% of the world population; this has not changed substantially since the species was classified as rare by COSEWIC (Mackay 1978).

The productivity (cygnets/adult-plumaged birds) of the Canadian population is very close to that of the Alaska population between 1968 and 1980 (King and Conant 1981: Table 1). That population has been growing at about 8% per year. If population-limiting factors are similar, the Canadian population might number about 670 adult-plumaged birds by 1990, and 1500 by the year 2000. However, the Grande Prairie flock has grown at a rate of about 11% per year since 1976. If that rate is applied over the Canadian range, approximately 2300 adult-plumaged birds might be expected in Canada by 2000.

There has been some concern that the Rocky Mountain population is limited by the quantity and quality of winter habitat available in the tri-state area. As the winter climate there is harsh, and the amount of open water is limited and controlled by a dam on key riverine habitat, winter mortality can be high. The same is not true of the winter habitat used by the Pacific coast population, whose growth rate seems to be lower than that of the Grande Prairie flock. Perhaps as the Canadian population continues to grow, pioneering into new winter habitat will occur in the tri-state area.

Given the presumed historic range of the species, the amount of breeding habitat available in Canada may be quite large, particularly in the boreal forest. However, it is not clear how swans pioneer into new territory. If they expand only from population centres, it is difficult to explain how new flocks have appeared so far from those centres. One possibility is that swans moving to traditional breeding areas explore favourable locations *en route*. That would

explain how satellite populations developed between Grande Prairie and southern Yukon Territory, but not the origin of the Yukon flock. That flock, however, could have become established by an interchange between the Pacific coast population and the Rocky Mountain population. Approximately 400 more Trumpeter Swans winter in the tri-state area than can be accounted for by the local population and the Canadian population combined. If some of those birds were from Alaska they might fly over areas of potential Trumpeter Swan habitat in western Canada, including Yukon Territory. So far, no birds banded in Alaska have been recorded in the tri-state area. But one bird banded in Powell River, British Columbia, in January 1984, presumably of the Alaskan population, was found dead near Cardinal Lake north of Grande Prairie, Alberta, in April 1985. Some exchange between the two populations may occur; it is unlikely that all the "extra" birds wintering in the tri-state area are coming from unknown Canadian areas.

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New and Significant Records of Ontario Sedges (Cyperaceae)

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The sedges *Carex aggregata*, *C. retroflexa*, and *C. glaucoidea*, collected in Essex County, are additions to the native flora of Canada. *Carex emoryi* from southern Ontario and *C. obtusata* from Rainy River district are new to Ontario. Two distinctive hybrid sedges, *C. X subimpressa* (*C. hyalinolepis* X *C. lanuginosa*) and *C. X sullivantii* (*C. gracillima* X *C. hirtifolia*), from southwestern Ontario, are new to Canada. *Carex assiniboinensis* from Rainy River District, and *C. inops* subsp. *heliophila* from Haldimand-Norfolk Regional Municipality, are confirmed as elements of the Ontario flora. Recent collections of four rare sedges, *C. leavenworthii*, *C. lupuliformis*, *C. shortiana*, and *Hemicarpha micrantha*, are documented from Essex County. *Carex frankii* is reported for the first time on the Canadian mainland in Essex and Elgin counties. Ecological data, morphological characters and illustrations will assist in the separation of these taxa from similar Ontario sedges.

Key Words: *Carex*, *Hemicarpha*, Cyperaceae, sedges, new records, floristics, phytogeography, Canada, Ontario.

Recent field work in Ontario has provided new Canadian and provincial records, collections of species not seen in the province for many decades, and confirmation of previously questionable or unverified records. In this paper we discuss significant new records of 14 sedge taxa; six new to Ontario, and four new to Canada. Thirteen of the 14 taxa discussed belong to the genus *Carex*, the largest in the Canadian flora. Scoggan (1978) lists 273 species of *Carex* in Canada, while Soper (1949) includes 142 for southern Ontario alone. Reznicek and Catling (1982, 1984) have recently reported six sedge additions to Canada's flora, and we expect that as field botanists continue to become more familiar with this family, additional discoveries will be made.

The sedges discussed below are all rare native taxa. The additions to Ontario's flora are included and mapped in the fourth installment of the Ontario rare plant atlas (Pryer and Argus 1988). Herbarium acronyms follow Holmgren et al. (1981). The label data for earlier collections of some species discussed are available in the Atlas of the Rare Plants of Ontario files at the National Museum of Natural Sciences (CAN).

Carex aggregata Mackenzie

This member of the section Bracteosae ranges from New York, Ohio, and southern Michigan to Iowa, south to New Jersey, Washington D.C., Kentucky, Missouri, and Oklahoma, but it has not previously been reported from Canada (Mackenzie 1931; Boivin 1967; Scoggan 1978). In Ohio, it is

infrequent, but ranges north to the south shore of Lake Erie in Lorain County (Braun 1967). In 1982, *Carex aggregata* was found to be scarce in dry clearings of an open Hackberry (*Celtis occidentalis*) forest over shallow limestone soil on Middle Island in Lake Erie. Voss (1972) mentions that the species is probably adventive at its only Michigan location in Kalamazoo County, but the Middle Island population is almost certainly indigenous. *Carex aggregata* closely resembles *C. grvida*, and the Middle Island collections were initially misidentified as *C. grvida* (Oldham 1983). Distinguishing features of *C. aggregata* include sheaths which are concave, thickened and often reddish-brown at the mouth; green perigynia exceeding the unawned (though acuminate) scales; and longer, more slender stigmas.

Specimens examined: ESSEX COUNTY: Middle Island, 2 June 1982, A. A. Reznicek 6681 et al. (DAO, MICH, TRTE), M. J. Oldham 2620 et al. (CAN, TRT); 7 June 1984, M. J. Oldham 4209 et al. (DAO, TRTE).

Carex assiniboinensis W. Boott

Primarily a midwestern species, *Carex assiniboinensis* is known in Canada from Manitoba and Saskatchewan (Hudson 1977; Scoggan 1978; Boivin 1979), and from the states of North Dakota, South Dakota, Iowa, Minnesota, Michigan, and Wisconsin (McGregor and Barkley 1977; Wheeler and Ownbey 1984; specimens in MICH). Ball and White (1982a) tentatively mapped the species from Ontario based on a vegetative specimen. A fertile

specimen collected in 1981, and subsequent collections from Rainy River District, confirm the occurrence of the species in Ontario. *Carex assiniboinensis* was found to be common in open, sandy parkland near the shore of Lake of the Woods. In Minnesota, it is uncommon but widespread, occurring in northern Lake of the Woods County (Wheeler and Ownbey 1984), about 20 km from the 1981 Ontario collection.

Carex assiniboinensis can be distinguished from other members of the section *Sylvaticae* by its remotely few-flowered pistillate spikes, and hispid perigynia with slender beaks nearly one-half as long as the lance-subulate body. In addition, it is the only species of *Carex* that produces both vegetative culms and pseudoculms (Reznicek and Catling 1986b). The long-arching stolons often form new plants upon reaching the ground, and can form extensive vegetative colonies (Tolstead 1946; Bernard 1959).

Specimens examined: RAINY RIVER DISTRICT: Budreau Beach, SE shore of Lake of the Woods, 25 May 1981, *W. J. Crins 3080 & R. Ridout* (TRTE); 20 August 1983, *W. J. Crins 6072* (TRTE). Lake of the Woods Provincial Park, 26 May 1984, *W. J. Crins 6314 & M. E. Dyer* (MICH, TRTE).

Carex emoryi Dewey

This primarily midwestern species is reported from Manitoba (Mackenzie 1935; Scoggan 1957, 1978 [sub *Carex stricta* var. *elongata*]). The specimens cited below, primarily from open sedge meadows along river bottoms, are the first Ontario collections. Recent field work has found *C. emoryi* to be fairly widespread along southwestern Ontario watercourses, including the Thames River, Sydenham River, St. Clair River, Grand River, Ausable River, and Catfish Creek. It is particularly common and widespread on the Thames River, and will undoubtedly be found elsewhere in southwestern Ontario. This species is similar to the common *C. stricta*, but is readily distinguished by having ligules as wide or wider than long, the lower leaf sheaths non-fibrillose, and the inner band of the leaf sheaths smooth.

Specimens examined: BRANT COUNTY: Grand River, 0.5 km NE of Glen Morris bridge, 21 June 1987, *M. J. Oldham 7454* (MICH, TRTE). ELGIN COUNTY: Catfish Creek at Port Bruce, 19 Sept. 1987, *M. J. Oldham 7836* (MICH). ESSEX COUNTY: Goodchild Beach at Lake Erie, 26 June 1987, *M. J. Oldham 6408* (MICH). KENT COUNTY: ca. 0.5 mi NW of Prairie Siding, N bank of Thames River, 10 July 1982, *A. A. Reznicek 6859 & S. A. Reznicek* (DAO, MICH); 10 June 1984, *M. J.*

Oldham 4225 (CAN, DAO, MICH, TRTE, UWO, WAT). LAMBTON COUNTY: Squirrel Island, 18 June 1985, *A. A. Reznicek 7511, M. J. Oldham & P. F. Maycock* (MICH). 1.5 km N of Sombra, E bank of St. Clair River, 6 Nov. 1985, *M. J. Oldham 5663* (MICH). Sydenham River, 1.25 km WSW of Shetland, 5 June 1987, *M. J. Oldham 7286* (MICH). MIDDLESEX COUNTY: NE side of London, S bank of Thames River, ca. 0.5 mi W of Fanshawe Lake dam, 23 July 1982, *A. A. Reznicek 6863* (DAO, MICH, TRT). Ausable River at Hungry Hollow, 23 June 1985, *M. J. Oldham 5020, S. J. Darbyshire & M. B. Delisle-Oldham* (DAO, MICH, TRT).

Carex frankii Kunth

Ball and White (1982b) mapped this species in Canada only from Pelee Island. There, it is locally common in moist ditches and marsh edges. The discovery of *Carex frankii* at three sites on the Ontario mainland, two in Essex County and one in Elgin County, suggests that it should be looked for elsewhere in southwestern Ontario. A vegetative specimen collected in 1984 on Middle Island, Essex County, confirms the report by Core (1948) for which we have seen no voucher.

The mainland Essex County sites are in an open, moist Red Ash (*Fraxinus pennsylvanica*) floodplain woods at Big Creek and a moist, open, recently drained wetland at Cedar Creek. In Elgin County, *C. frankii* was found at the edge of a trail in floodplain woods, in moist sandy loam. It is a distinctive species, with its relatively small achenes (ca. 1.5 mm long) topped by the persistent style, usually wholly staminate terminal spike, long-awned pistillate scales exceeding the perigynia, and broad ribbon-like bracts greatly overtopping the culms.

Specimens examined: ESSEX COUNTY: Big Creek floodplain, 3 km NE of Amherstburg, 23 June 1981, *M. J. Oldham 1533 & S. Managhan* (CAN, TRTE). Big Creek floodplain, just N of Malden-Anderdon townline, 12 July 1982, *M. J. Oldham 3011* (TRTE). Middle Island, 7 June 1984, *M. J. Oldham 4214 et al.* (MICH). Cedar Creek, 15 July 1984, *M. J. Oldham 4342 & G. M. Allen* (TRTE). ELGIN COUNTY: Dunwich Tp., Lot 23, Conc. 11, 12 Sept. 1984, *D. McLeod 160-84* (OAC, TRTE, UWO).

Carex glaucoidea Tuckerman

Although this sedge has previously been reported from Ontario (Mackenzie 1935; Fernald 1950; Gleason 1952; Gleason and Cronquist 1963; Scoggan 1978), Boivin (1967) excluded it, and Ball

et al. (1982) found no correctly determined Ontario material. *Carex glaucoidea* is not known from adjacent southern Michigan (Voss 1972), but it occurs from Indiana, Illinois, Ohio, New York, and Massachusetts, south to Alabama and Louisiana (Mackenzie 1935; Fernald 1950). Many authors treat this as *C. flaccosperma* Dewey var. *glaucoidea* (Tuckerman) Kükenthal.

In 1982, *Carex glaucoidea* was collected from woods along the Canard River in Essex County, but it could not be relocated in later visits to the site. In 1985 the species was found to be locally common in two habitats at the Caistorville-Canborough Slough Forest in Haldimand-Norfolk Regional Municipality. *Carex glaucoidea* was found on dry-mesic clay soil in openings of a mature, open White Oak (*Quercus alba*) woodland, with regenerating Red Maple (*Acer rubrum*) and Trembling Aspen (*Populus tremuloides*), and a Poverty Grass (*Danthonia compressa*)-dominated herb layer. It also grew in an open hawthorn-meadowsweet (*Crataegus pruinosa*-*Spiraea alba*) meadow on mesic clay soil.

Ontario material of *Carex glaucoidea* is most easily confused with *C. amphibola* and *C. granularis*. It can be distinguished from *C. amphibola* by its thick, glaucous foliage, relatively densely flowered spikes (up to 20 to 25 perigynia), and awnless or short-awned pistillate scales, and from *C. granularis* by its beakless perigynia.

Specimens examined: ESSEX COUNTY: 7.5 mi NW of Harrow, along Canard River, 14 June 1982, *M. J. Oldham* 2780 (CAN, MICH, TRTE). HALDIMAND-NORFOLK REGIONAL MUNICIPALITY: Caistorville-Canborough Slough Forest, 3.5 km NNW of Canborough, 24 June 1985, *M. E. Gartshore* 85173 (MICH, TRTE); 19 July 1985, *M. J. Oldham* 5219, *D. A. Sutherland* & *M. E. Gartshore* (DAO, MICH, TRT).

***Carex inops* Bailey subsp. *heliophila* (Mackenzie) Crins**

This sedge was first collected in Ontario in 1960 by H.J. Scoggan at Turkey Point by Lake Erie. It has been variously recognized as a variety of *Carex pensylvanica* Lamarck (var. *digyna* Böckeler) or as a distinct species (Mackenzie 1935; Fernald 1950; Gleason and Cronquist 1963; Scoggan 1978). However, the recent revision by Crins and Ball (1983) clearly indicates that this taxon is most closely related to the western *C. inops*. It is characteristic of the dry mixed-grass and short-grass prairies of western Manitoba, Saskatchewan, Alberta, and the northern prairie states.

A number of previous reports for Ontario were

based on misidentifications or uncritical applications of varietal names to typical plants of *C. pensylvanica* (Fernald 1950; Scoggan 1978). It appears that no effort had been made to relocate this taxon in Ontario since its original discovery by Scoggan. In 1980, a search of potential sites in the vicinity of Turkey Point revealed its continued presence there. The population is small (ca. 10×10 m), and is situated in a sandy opening among native and planted trees (*Quercus velutina*, *Pinus* spp.), in association with *Linum sulcatum*, *Lespedeza* spp., *Tephrosia virginiana*, *Poa pratensis*, *Cyperus filiculmis*, and *Euphorbia corollata*. It can be distinguished from the similar *C. pensylvanica* and *C. lucorum* by its larger perigynia (1.8 – 2.5 mm long $\times$ 1.7 – 2.2 mm wide), shallowly concave sheath mouths, and long-acuminate, pale brown staminate scales.

Specimens examined: HALDIMAND-NORFOLK REGIONAL MUNICIPALITY: Turkey Point, by Lake Erie, 13–14 July 1960, *H. J. Scoggan* 14272 (CAN, TRT); ca. 1.5 km N of Turkey Point, on W side of main road, 28 June 1980, *W. J. Crins* 2615 (TRTE); ca. 200 m W of Turkey Point Rd. — old Lakeshore Rd. junction, 24 May 1982, *W. J. Crins* 4196 (TRTE).

***Carex leavenworthii* Dewey**

On 15 June 1882, John Macoun collected this species on Pelee Island, where it grew in dry, rocky places. For over 100 years this remained the only Canadian collection, despite specific searches for it. In 1984, *Carex leavenworthii* was rediscovered on dry, shallow soil over limestone at the Stone Road alvar on Pelee Island.

Carex leavenworthii is easily confused with *C. cephalophora*, but can be distinguished by its perigynia which are 3/5 to 3/4 as wide as long (actual range of ten measurements from *Oldham* 4275 are 0.55 to 0.72 times as wide as long, mean 0.62), widest near the base, broadly rounded to truncate basally, and with the beak only sparsely serrulate or even smooth (Figure 1). In addition, the leaves are narrower than in *C. cephalophora* (widest leaves 1.6 – 3.2 mm compared to 2.4 – 5.3 mm; range of measurements on specimens at MICH), and the long, spreading culms frequently surpass the leaves in *C. leavenworthii*.

On Pelee Island, *Carex leavenworthii* grows in an undisturbed alvar with other rare native species; however, in southern Michigan it sometimes occurs in weedy habitats (Voss 1972; A. A. Reznicek, personal communication, 1984). In the United States, *C. leavenworthii* ranges south to Florida and Texas (Mackenzie 1931).

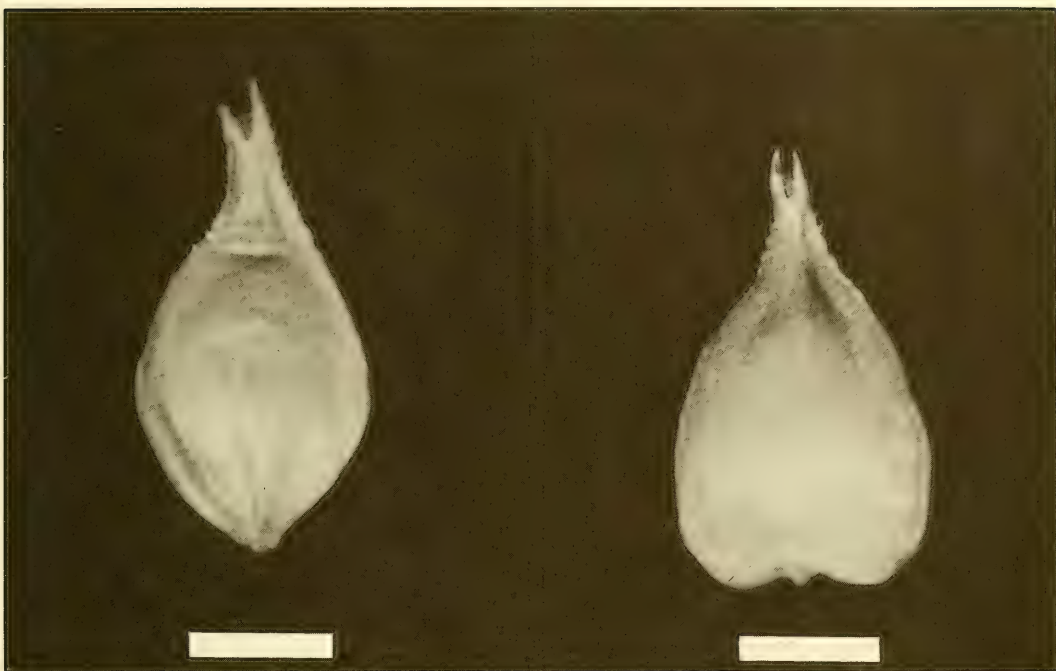


FIGURE 1. *Left*, perigynium of *Carex cephalophora* (Ontario, Kent Co., Wheatley, *R. Klinkenberg* 550, MICH); *right*, perigynium of *Carex leavenworthii* (Ontario, Essex Co., Pelee Is., *M.J. Oldham* 4275, MICH). Bar equals 1 mm.

Specimens examined: ESSEX COUNTY: Pelee Island, Stone Road alvar, 24 June 1984, *M. J. Oldham* 4275 *et al.* (MICH, TRTE); 13 May 1985, *M. J. Oldham* 4755 (TRTE).

Carex lupuliformis Sartwell

Herriot collected the first Ontario specimen of *Carex lupuliformis* in 1902 near Galt. In 1985, A. A. Reznicek rediscovered the species in the province, growing with Buttonbush (*Cephalanthus occidentalis*) in an open ash-willow forest near Amherstburg, Essex County. At the site near Amherstburg, about 15 scattered clumps of *C. lupuliformis* were found, growing with the similar *C. lupulina*. *Carex lupuliformis* is larger in all dimensions than *C. lupulina*. The best distinguishing feature is the presence of knobbed angles on the achenes of *C. lupuliformis*. The two species are a very close pair and careful examination is needed to separate them (Reznicek and Ball 1974). *Carex lupuliformis* ranges from southwestern Quebec west to southeastern Minnesota, and south to Louisiana (Ball and White 1982c).

Specimens examined: ESSEX COUNTY: 4.5 km NE of Amherstburg on Big Creek, 29 July 1985,

A. A. Reznicek 7587, *M. J. Oldham* & *W. Botham* (CAN, DAO, MICH), *M. J. Oldham* 5309, A. A. Reznicek & *W. Botham* (TRTE).

Carex obtusata Liljeblad

This species represents an addition to Ontario's flora. It occurs on an open, dry, granitic outcrop with small, thin seams of shallow soil in Rainy River District. It is a common prairie species in western Canada, ranging from southern Manitoba to British Columbia (Boivin 1979).

Carex obtusata can be distinguished from the similar *C. filifolia* by its tough, blackish, cord-like rhizomes; glabrous, dark brown to black perigynia (those of *C. filifolia* are minutely puberulent at the summit and pale in colour); and rachillae in the perigynia (occasionally with a scale-like appendage at the apex). Another early-flowering, dry prairie species, *C. eleocharis*, is superficially similar, but *C. obtusata* possesses three stigmas and a rachilla.

Specimens examined: RAINY RIVER DISTRICT: 3.5 km W of Harris Hill, 27 May 1984, *W. J. Crins* 6318 & *M. E. Dyer* (CAN, MICH, TRT).

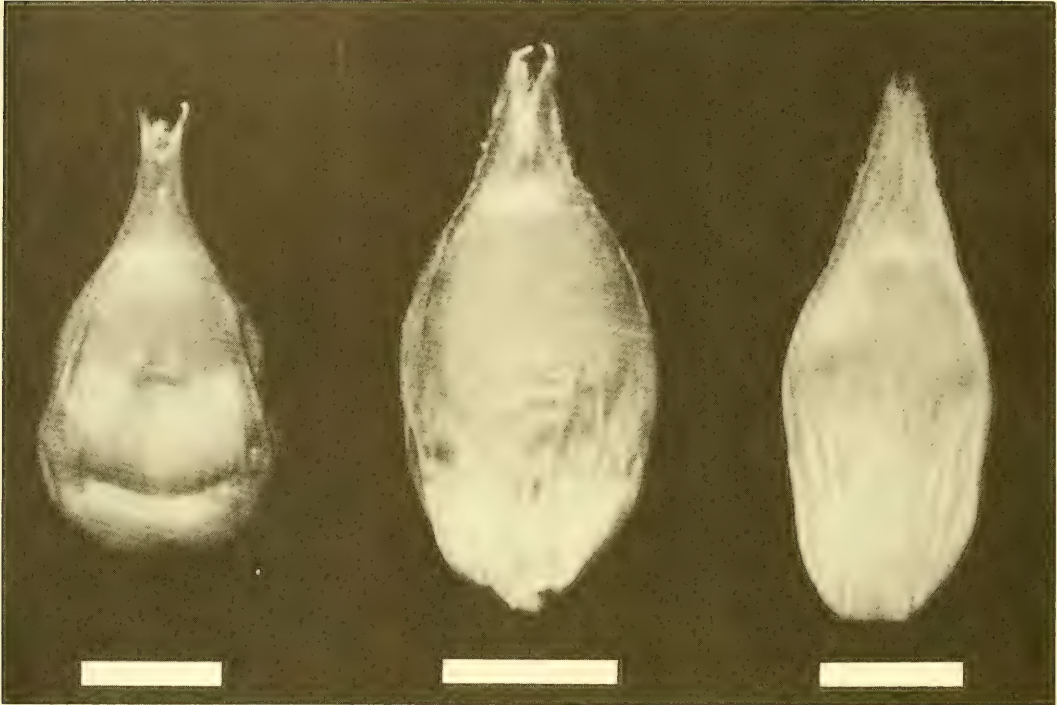


FIGURE 2. *Left*, perigynium of *Carex retroflexa* (Ontario, Essex Co., Cedar Creek, *M.J. Oldham* 4257, MICH); *centre*, perigynium of *Carex rosea* (Ontario, Essex Co., 5 km SE of Harrow, *M.J. Oldham* 2719, MICH); *right*, perigynium of *Carex radiata* (Ontario, Essex Co., Pelee Is., *A.A. Reznicek et al.* 6683, MICH). Bar equals 1 mm.

Carex retroflexa Willdenow

Previous reports of this species in Canada (Scoggan 1978) are all based on misidentified Ontario collections, and it was excluded from consideration in the *Atlas of the Rare Vascular Plants of Ontario* (Ball et al. 1982). South of Canada, *Carex retroflexa* occurs from Vermont to southern Michigan and south to Florida and Texas (Mackenzie 1931). In Essex County, it has recently been collected from fairly dry, grassy openings in rich hardwoods and grassy woodland edges in the Cedar Creek area and near Harrow.

Carex retroflexa is a member of section Bracteosae, and is superficially similar to *C. radiata* (*C. rosea* auct.) and *C. rosea* (*C. convoluta* auct.), both common woodland sedges in southern Ontario (Webber and Ball 1985). All three species grow in close proximity to one another at a woodlot near Harrow. *Carex retroflexa* is best distinguished from *C. radiata* and *C. rosea* by its smooth perigynium beak, in contrast to the minutely serrulate beak of the latter two species

(Figure 2). The spongy, distended, and often dark-coloured perigynium base of *C. retroflexa* is also distinctive (Figure 2).

Specimens examined: ESSEX COUNTY, woods 2 km NE of Harrow, 22 May 1981, *M. J. Oldham* 2427 (CAN, MICH, TRTE); 19 June 1983, *M. J. Oldham* 3841 et al. (CAN, TRTE); 19 June 1983, *A. A. Reznicek* 7156 et al. (DAO, MICH). Cedar Creek, 7 km WSW of Kingsville, 19 June 1983, *A. A. Reznicek* 7172 et al. (DAO, MICH); 19 June 1983, *M. J. Oldham* 3843 et al. (TRTE).

Carex shortiana Dewey

Ball and White (1982d) recorded a single location of *Carex shortiana* in Canada, based on John Macoun's 1901 specimen from Amherstburg. A 1955 specimen in DAO collected from along the Canard River was overlooked by Ball and White (1982d), although Boivin (1967) mentions *C. shortiana* from "riv. aux Canards". In 1984, on the wooded floodplain of Big Creek in Essex County, and in an adjacent roadside ditch, *C. shortiana* was

rediscovered. This is probably the same location where Macoun collected the species, since it is only 2 km from Amherstburg and is very near a siding of the old Canada Southern Railway (C.S.R.) which ran between Amherstburg and Toronto. Other Macoun collections (eg. *Hordeum pusillum* and *Plantago cordata*) are specifically labelled as having been collected along the C.S.R.

Carex shortiana is a very distinctive species, with its brown, transversely wrinkled, wide, beakless perigynia; brown, broad-ovate pistillate scales with a green midrib; and gynecandrous terminal spike. In the United States, *C. shortiana* ranges from Pennsylvania to Indiana, Iowa and Kansas, and south to Tennessee (Mackenzie 1935). Although it is common and widespread in Ohio, including the northwest (Braun 1967), it has yet to be found in Michigan (Voss 1972).

Specimens examined: ESSEX COUNTY: 6 mi NE of Amherstburg along Canard River, 24 June 1955, *J. A. Calder 15927* & *L. J. Van Rens* (DAO). Big Creek floodplain, 3.5 km NE of Amherstburg, 21 June 1984, *M. J. Oldham 4254 et al.* (MICH, TRTE).

Carex X subimpressa Clokey

Reznicek and Catling (1986a) have recently demonstrated conclusively that *Carex X subimpressa* is a hybrid between *C. hyalinolepis* and *C. lanuginosa*. The hybrid grows in relatively open, periodically moist areas, often ditches, usually with one or both parents. *Carex X subimpressa* is intermediate in most characters between its parents, both of which are common in Essex County. This hybrid has not previously been reported from Canada, but it is known from Michigan (Hermann 1941; Voss 1972), Indiana (Hermann in Deam 1940), Illinois (Clokey 1916; Jones and Fuller 1955), and Missouri (Steyermark 1963). Reznicek and Catling (1986a) thoroughly discuss the status, distribution and identification of *C. X subimpressa*.

Specimens examined: ESSEX COUNTY: 2.6 mi W of Deerbrook, 10 July 1982, *A. A. Reznicek 6854* & *S. A. Reznicek* (DAO, MICH, TRTE); 1 July 1983, *M. J. Oldham 3888* (CAN, TRTE). 2 km NE of Harrow, 19 June 1983, *A. A. Reznicek 7167 et al.* (MICH). 3.5 km NE of Amherstburg, 28 June 1984, *A. A. Reznicek 7378 et al.* (DAO, KE, MICH, TRTE, WAT) (this clone is possibly a backcross to *C. hyalinolepis*). 1 km W of Kingsville, 29 July 1985, *A. A. Reznicek 7588* & *M. J. Oldham* (MICH). KENT COUNTY: Hwy. 401 at Hwy. 40 to Chatham, 18 June 1983, *M. J. Oldham 3817* (MICH, TRTE); 3 June 1984, *M. J.*

Oldham 4199 (DAO, MICH, TRTE). LAMBTON COUNTY: Walpole Is., 30 June 1986, *M. J. Oldham 6421 et al.* (MICH). 5.25 km WNW of Oil Springs, 1 July 1987, *M. J. Oldham 7499* (MICH).

Carex X sullivantii Boott in Gray (pro sp.)

Carex X sullivanti is a distinctive, very rare hybrid between *C. gracillima* and *C. hirtifolia*, two fairly common woodland sedges. This is the first Canadian collection of a hybrid previously known from only three sites since its original discovery in the mid-1800s (Boott 1858; Bill 1930; Mackenzie 1935). *Carex X sullivantii* was collected from rich hardwoods on sandy soil near Cedar Creek, but could not be relocated on subsequent visits. The features distinguishing this hybrid from its parents and *C. arctata* include pilose culms, leaves, sheaths, and perigynia; erect, often compound spikes; and obtuse, often emarginate scales.

Specimens examined: ESSEX COUNTY: Cedar Creek, 18 June 1981, *M. J. Oldham 1504* & *S. Managhan* (MICH, TRTE).

Hemicarpha micrantha (Vahl) Pax

This minute sedge was collected in 1892 and 1901 by John Macoun on wet sand along the Detroit River south of Amherstburg. Today the Canadian side of the Detroit River south of Amherstburg is intensively developed, and homes or various types of shore protection line its bank. The few remaining small sandy beaches have been searched unsuccessfully for *Hemicarpha*. However, it was found on 30 July 1984 on a moist sand beach west of Holiday Beach Provincial Park on Lake Erie. About 15 plants were located in the open, growing with *Cyperus aristatus*, *C. rivularis*, *C. strigosus*, *C. ferruginescens*, *C. engelmannii*, *Bidens cernua*, *Salix fragilis* (seedlings), *S. exigua* (seedlings), and other moist sandy shoreline species. *Hemicarpha micrantha* is easily overlooked in the field because of its small size. In Michigan it frequently occurs on sandy-mucky shores of receding lakes, often in association with Coastal Plain disjuncts (Voss 1972). Population size may vary widely from year to year in response to water-level fluctuations. It is probable that buried seed banks and water-level fluctuations, as described by Keddy and Reznicek (1982), are essential to the long-term survival of *H. micrantha* populations.

Although *H. micrantha* is widely distributed in the Americas, being found from coast to coast and south into northern South America (Friedland 1941), it is apparently quite rare in Canada. Elsewhere in Canada, it is known from southwest-

ern Quebec (Scoggan 1978) and southern British Columbia (Ceska and Ceska 1980). *Hemicarpha micrantha* should be looked for in other moist, sandy locations in southwestern Ontario.

Specimens examined: ESSEX COUNTY: beach W of Holiday Beach Provincial Park, 10 km SE of Amherstburg, 30 July 1984, *M. J. Oldham* 4448 & *M. Brunton* (TRTE); 23 Sept. 1985, *M. J. Oldham* 5593 & *D. A. Sutherland* (MICH).

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Observations on the Diel and Seasonal Drift of Eggs and Larvae of Anadromous Rainbow Smelt, *Osmerus mordax*, and Blueback Herring, *Alosa aestivalis*, in a Coastal Stream on Prince Edward Island

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A diel and seasonal periodicity in drift from the West River (mean annual flow $0.022 \text{ m}^3 \cdot \text{sec}^{-1} \cdot \text{km}^2$) was evident for eggs and larvae of anadromous Rainbow Smelt and Blueback Herring. Spawning of smelt and blueback occurred usually between dusk and 1 am. Drift of all egg stages and larvae increased at night between 10 pm and 4 am with a peak usually between 12 pm and 2 am. When mean daily water temperatures were below 13°C drift densities of egg and larvae of both species were always greater at night than during the day. However, when mean daily water temperatures were above 15°C , the abundance of larval Blueback Herring in the drift increased in the daytime and decreased at night. Forty-one percent and 26% of the egg drift consisted of dead smelt and blueback eggs respectively. Eggs in different stages of development and prolarvae were carried passively to the estuary where they entered salinities of $18\text{--}22^\circ/\text{oo}$. Survival of the larvae and eggs suggest that both species are very tolerant to high salinities at an early stage of development. The importance of estuaries as nursery areas for these species is discussed.

Key Words: Rainbow Smelt, *Osmerus mordax*, Blueback Herring, *Alosa aestivalis*, eggs, larvae, Prince Edward Island.

Annually, each spring and early summer anadromous Rainbow Smelt (*Osmerus mordax*), Alewives (*Alosa pseudoharengus*), and Blueback Herring (*Alosa aestivalis*) ascend the coastal streams of Prince Edward Island to spawn. All three species normally spawn above the head of tide in fast flowing water and spread eggs over the bottom where they adhere to sticks, stones, gravel and aquatic vegetation (Scott and Crossman 1973). Hatching occurs in 3-20 days depending on water temperature (Hoover 1936; McKenzie 1964; Leim and Scott 1966; Edsall 1970; Cooper 1978). Larvae that hatch from the eggs have large yolk-sacs and a limited swimming ability (Cooper 1978; Chambers et al. 1976). Such larvae upon hatching are carried into the currents and swept downstream to slower moving water where they grow and develop into juveniles.

Most studies on smelt and Blueback Herring have concentrated on the adult stage. Some life history information has been published already for both species (Langlois 1935; Bigelow and Schroeder 1953; McKenzie 1964; Leim and Scott 1966; Scott and Crossman 1973; Messieh 1977). Few studies, however, have been undertaken on the egg or larval stages.

In Prince Edward Island smelts, Alewives and Blueback Herring are important species being

fished commercially and for bait in lobster fishing. In addition, the eggs and larvae are important foods for young salmonids and probably other marine species (Johnston 1980). Unfortunately, the Blueback Herring is a poorly-known species and seldom distinguished from the Alewife. In Nova Scotia and elsewhere the Blueback Herring was considered rare and endangered (McAllister 1970; Isnor 1981), although its rarity was overestimated (Dadswell 1985).

The present study was undertaken in the spring and summer of 1984 to describe the diel and seasonal changes in egg and larval release of smelt and Blueback Herring in a short coastal system.

Description of Study Area

The West River is situated on the southern coast of Prince Edward Island and flows into Charlottetown Harbour (Figure 1). This is one of the larger river systems (length 94.45 km, mean annual flow $0.022 \text{ m}^3 \cdot \text{sec}^{-1} \cdot \text{km}^2$) and except for a small pond approximately 1.5 km above the Trans Canada Highway, the river flows unimpeded into the estuary. Thirty-two percent of the land in the watershed area is forested and 68% cleared. The head of tide is just below the Trans Canada Highway at Bonshaw. Water depth in this area of the river ranges between 1-2 m and the width between

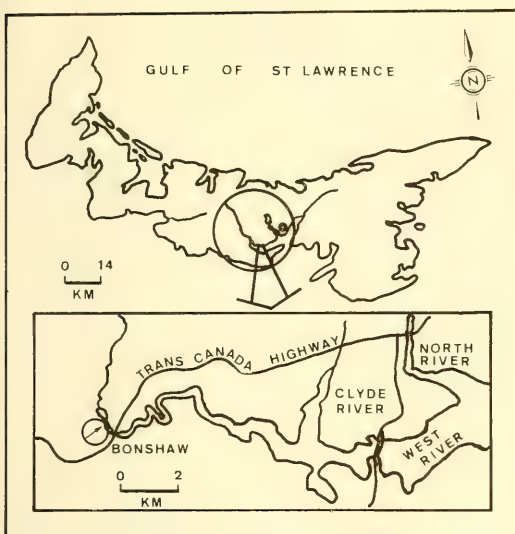


FIGURE 1. Location of the sampling site on the West River, Prince Edward Island.

15–20 m depending on tidal cycle and a prominent saltwater wedge lies underneath the freshwater outflow. Salinities on the bottom in the wedge were between 18.0–22.0 ‰, while at the surface they were 0.1–1.1 ‰. More complete mixing of salt and fresh water occurs further down stream, approximately 2 km from Bonshaw. At this point surface and bottom salinities were 21 ‰ and 23 ‰ respectively.

Materials and Methods

Drifting eggs and larval fish were collected every hour of each twenty-four hour sampling period from a site 1 km above the head of tide on the West River (Figure 1). Twenty-four hour sampling periods were on the following days: 6–7, 8–9, 13–14, 16–17, 19–20, 22–23, 25–26, 28–29 June; 1–2, 4–5, 7–8, 10–11, 13–14, 16–17, 19–20, 22–23, 25–26, 28–29 July; 2–3, 5–6 August. A plankton sampler having a rectangular opening of 80.0 × 30.5 cm and a conical 2 m net with a mesh size of 505 μ was placed vertically in the central current flow and held there for exactly 10 min. All eggs and larvae in the water from river bottom to surface passing into the sampler were collected. A calibrated flowmeter positioned in the center of the rectangular frame was used to obtain a quantitative estimate of the volume of water filtered. Following each sampling, the contents of the net were removed and immediately preserved in 5% buffered formalin. Water temperature, water

turbidity, weather conditions and light conditions were also recorded with each sampling.

Fish eggs and larvae were stored in the dark until sorting and identification could be undertaken. Eggs were staged according to the following embryonic development:

Stage	Description
1	unfertilized eggs and eggs showing early blastula development
2	eggs in early embryonic development with the embryo not exceeding $\frac{1}{2}$ the yolk surface; eyes not developed
3	eggs with the embryo covering $\frac{3}{4}$ of the yolk surface; eyes developed
4	eggs with a tail-free embryo

Eggs were considered dead when they were deformed, with fungus, showed unnatural development or were opaque. Smelt eggs were easily distinguished from blueback eggs by the stalk-like attachment membrane of the chorion. Blueback eggs, although adhesive initially, were without this attachment membrane. Smelt and blueback larvae were classified either as prolarvae (with a yolk sac) or postlarvae (without a yolk sac). Smelt prolarvae were easily distinguished from blueback prolarvae by the presence in smelts of a large oil droplet in the anterior part of the yolk sac, the greater distance of the yolk-sac from the head and greater body length. Postlarvae were identified using the characteristics described by Cooper (1978), and MacLellan et al (1981). All eggs and larvae in each sample were counted and the abundance expressed as number per 100 m³ of water passing through the net.

Results

Diel and Seasonal Drift Periodicities

A diel and seasonal periodicity in drift was evident for eggs and larvae of smelt and Blueback Herring. A pronounced increase in drift of all stages occurred at night between 10 pm and 4 am with a peak usually between 12 pm and 2 am (Figure 2, 3, and 4). A "bigeminous" pattern similar to that described by Waters (1965, 1972) for invertebrates, was not evident for eggs or larvae of smelt and blueback. Drift densities of egg and larvae of both species were always lower during the day than at night when water temperatures were below 13°C. However, when water temperature rose above 15°C during the day time, the daytime abundance of larval blueback in the drift increased and the abundance at night decreased (Figure 5).

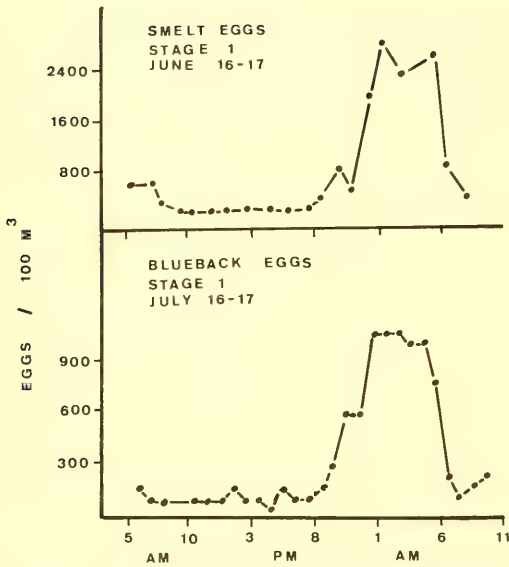


FIGURE 2. Diel abundance of the andromous Rainbow Smelt and Blueback Herring stage 1 eggs in the drift.

A total of 144 798 smelt and 653 706 blueback eggs were staged (Table 1) from the 18 days of sampling. Forty-five percent of the smelt egg drift consisted of stage 1 eggs; only a small number of stage 2, 3, 4 eggs were observed. Forty-one percent of the smelt egg drift consisted of dead eggs. Blueback eggs in the drift were also mostly stage 1 eggs and only a small number of intermediate stages were observed. Dead blueback eggs, represented 26% of the eggs and this level was much lower than that for smelts.

A total of 38 282 larvae were collected; 30% were smelts and 70% blueback. Most larvae were prolarvae; few were postlarvae.

The pattern of smelt egg and larval drift shown in Figure 6 represents only the late part of the smelt run. Due to technical difficulties it was not possible to sample the early part of the smelt run in May.

Seasonal drift densities for late-running smelts peaked to June and coincided with a mean daily water temperature of 9 to 11°C. (Figure 6). The larvae of smelts increased in early June due to hatching of eggs laid down by smelts early in the run. Thus the peak abundance of larvae does not coincide with egg release from smelts later in the run. The two most abundant egg stages in the drift were stage 1 and dead eggs. By mid-July smelt eggs and larvae were no longer present in the drift.

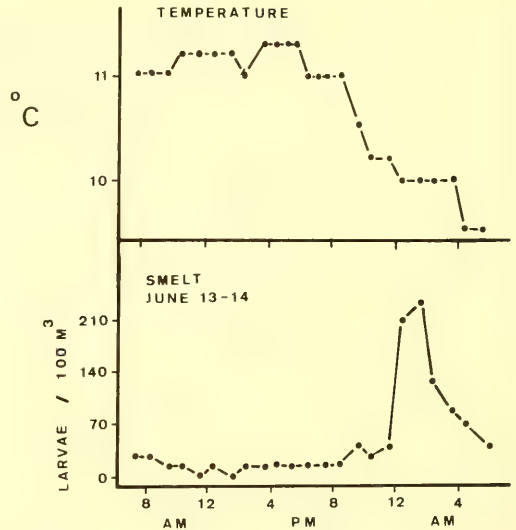


FIGURE 3. Diel abundance of Rainbow Smelt larvae in the drift. Water temperatures recorded at the sampling site are shown for that day.

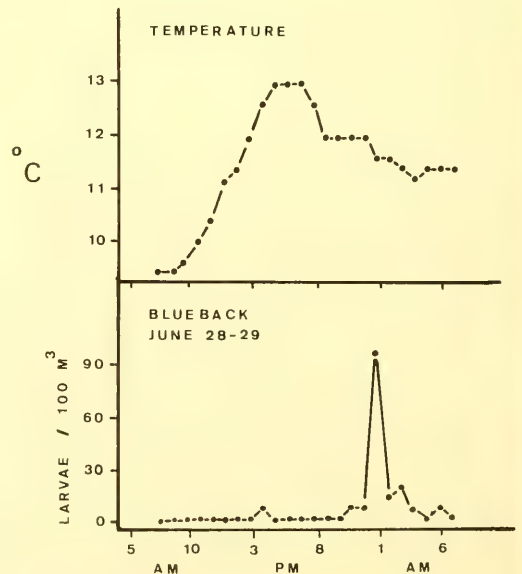


FIGURE 4. Diel abundance of Blueback Herring larvae in the drift. Water temperatures recorded at the sampling site are shown for that day.

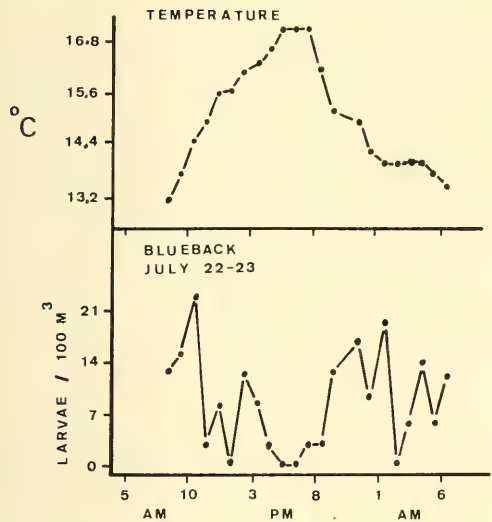


FIGURE 5. Diel abundance of Blueback Herring larvae in the drift. Water temperatures recorded at the sampling site are shown for that day.

Seasonal drift of blueback larvae and eggs peaked in the first two weeks of July when mean water temperatures were between 14–15°C (Figure 7). Adult blueback were first observed at the head of tide at Bonshaw on 8 June and upstream migrations did not occur to any extent until 21 June when water temperature was between 13–15°C. By August eggs and larvae were no longer in the drift.

Discussion

The downstream displacement or drift of fish eggs may occur as a consequence of (1) spawning activity, (2) loss of adhesiveness of the egg membrane, (3) increased velocity of stream flow, (4) attachment of eggs to floating vegetation or (5) dislodgement of eggs by man or animal activities in

the river. The present study suggests that spawning activity and stream discharge influence the level of drift the most. Based on the abundance of stage 1 eggs in the drift, most spawning of smelt and blueback occurs between dark and 1 a.m. This agrees with McKenzie's (1964) report that 80% of smelts spawn in the Miramichi river at night, but does not agree with Loesch and Lund's (1977) report that blueback in the Connecticut River spawn in the late afternoon. The absence of stage 2 smelt eggs and small numbers of stage 3 eggs in the drift suggests that the chorionic membrane is very adhesive at this stage and holds the egg firmly to the substratum after fertilization. During stage 4 the strength of this adhesiveness appears to be reduced for a much larger number of eggs were released to the drift. Higher water temperature or enzymes associated with hatching may be responsible for this loss of membrane adhesiveness.

During periods of increased stream flow there was approximately double the number of stage 4 smelt eggs in the drift. This suggests that increased turbulence and velocity of flow can detach more easily eggs adhering to rocks or bottom debris in advanced stages of development.

Blueback Herring eggs are demersal and less adhesive than smelt eggs (Kuntz and Radcliffe 1918). Apparently the eggs are adhesive during the water's "hardening period", but less adhesive thereafter, and easily dislodged. Although blueback eggs are less adhesive than smelt eggs, the pattern in the drift was similar. The data suggest also the spawning activities of bluebacks may dislodge more eggs than those of smelts.

Floating aquatic vegetation was collected in the plankton net; most was *Spirogyra*. Although eggs were found adhering to the filaments much of this attachment probably occurred after mixing in the net. Other aquatic vegetation had few eggs adhering to it.

Egg dislodgement by fishermen wading in the river as they fished for trout or by animals searching

TABLE 1. Summary of the number and percentage of Rainbow Smelt and Blueback Herring egg stages and larvae in drift samples from the West River.

Parameter	Species	Larvae	Egg stages					Total
			1	2	3	4	Dead	
Number Observed	Smelt	11338	65564	1963	4512	13924	58835	144798
	Blueback	26944	433078	4139	11805	35172	169512	653706
Percentage of total	Smelt	29.6	45.3	1.4	3.1	9.6	40.6	
	Blueback	70.4	66.4	0.6	1.8	5.3	25.9	

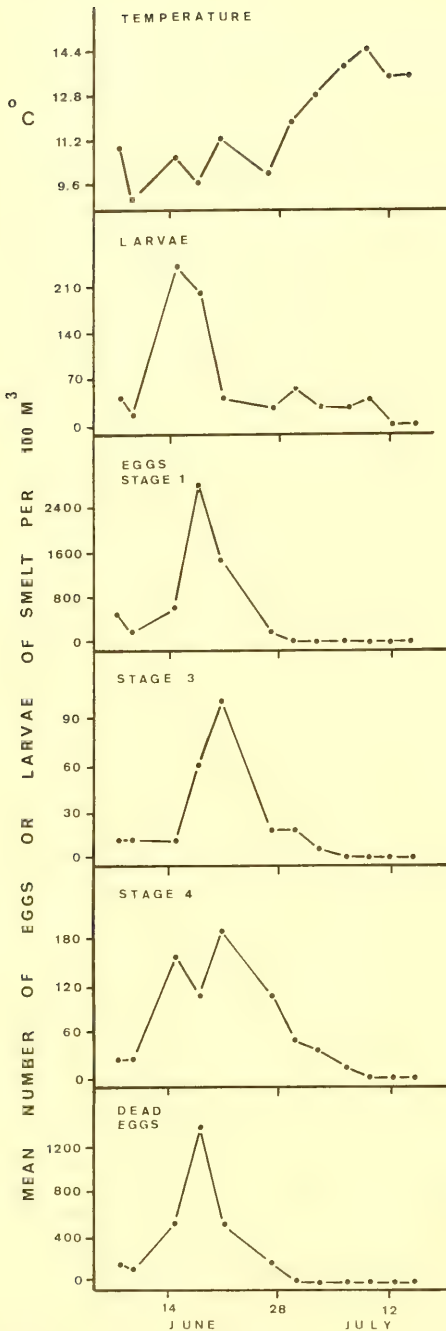


FIGURE 6. Seasonal mean daily abundance of Rainbow Smelt eggs in different stages of development and larvae in the drift. Mean daily water temperatures recorded at the sampling site are shown for the study period.

for food could also increase egg drift. During the study period we observed few fishermen wading in the river nor did we see an increased drift of eggs between 6–10 am or pm when fishing pressure was the heaviest. Only the occasional Muskrat, Mink or Raccoon was observed on the shore or swimming. These observations suggest that animal activities could not greatly alter egg release during the sampling period.

The total length of smelt larvae in the drift ranged between 5.33–6.16 mm and of Blueback Herring larvae 4.16–5.00 mm. These lengths indicated recently hatched larvae (Cooper 1978; Mansueti 1956). The appearance of large numbers of larvae at night suggest that either hatching occurs at this time or that newly hatched larvae are nocturnally disoriented. The limited swimming ability of the larvae favors the former. Nocturnal hatching seems to be an adaptive mechanism for both species allowing displacement to the estuary at a time when predation is low. Nocturnal hatching appears also to be a function of the spawning time and water temperature. When water temperatures are warm the periodicity of night-time hatching is lost. Comparing the larval abundance patterns, there appears to be little overlap in spawning and hatching times for the two species and probably little competition for a common food resource.

Knowledge of the egg and larval densities and mortality levels combined with adult female fecundity levels and male:female ratios may make it possible to estimate the size of the female spawning population in a river system. This study demonstrates that egg and larval sampling must be taken during peak release periods. Knowledge of the daily and seasonal patterns is important and may vary with water temperature.

Eggs and larvae of both species drift passively with the currents into the estuary. Plankton tows taken below Bonshaw showed that living egg and larvae were present at the surface and bottom. For example, samples of 7, 12 and 2 blueback larvae were collected on 24, 27 July and 5 August 1984 having total lengths ranging between 5.0 and 6.0 mm (mean 5.2 mm), 8.0 and 13.0 mm (mean 10.3 mm) and 7.0 and 9.0 mm (mean 8.0 mm), respectively. This suggested that eggs and larvae can tolerate salinities as high as 18–22 ‰. Nichols and Breder (1926) and Hildebrand (1963), reported blueback spawning in brackish water or above the head of tide, but did not describe salinity tolerance limits. Chittenden (1972) observed that Blueback Herring larvae are highly salinity tolerant early in life, allowing the species to utilize

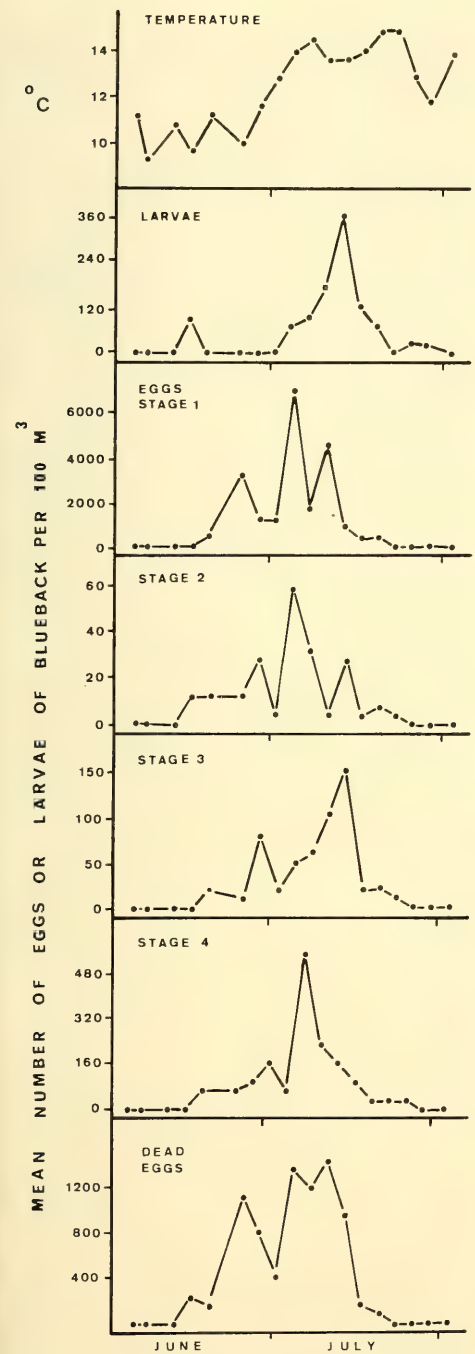


FIGURE 7. Seasonal mean daily abundance of Blueback Herring eggs in different stages of development and larvae in the drift. Mean daily water temperatures recorded at the sampling site are shown for the study period.

both freshwater and marine nurseries. He reported that fish of 34–47 mm could tolerate 28 ‰ salinity. McKenzie (1964) observed that smelt larvae were carried back and forth with the tide and that during the day larvae were on the bottom and at night near the surface. The present study shows that younger stages such as eggs and protol larvae can tolerate salinities as high as 22 ‰ and that estuaries of Prince Edward Island are important nursery areas for these stages. Further investigations are needed to determine more precisely the salinity tolerance and mortality level of eggs at different stages of development and of newly hatched larvae in saline conditions.

Euryhaline tolerance of egg and larvae of smelt and Blueback Herring permits these species to utilize both freshwater and the saline environment of Prince Edward Island estuaries for early development. Successful growth and development in both environments may provide better survival, growth of the young and larger populations.

Alterations in the circulation of estuaries due to causeway construction or the addition of pollutants can markedly alter the success of these early stages and affect the fishery. This was observed in the West River in late August 1984 when a combination of high water temperatures, excessive eutrophication, and poor circulation in the estuary caused the water in the nursery area to become depleted of oxygen and a large mortality of juveniles occurred. The effect of such a kill on the total population of smelt and Blueback Herring has not been documented, but future causeway construction should consider the impoundment effect on such important nursery areas.

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Bitterroot, *Lewisia rediviva*, in Southwestern Alberta: Cultural versus Natural Dispersal

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A recently reported occurrence of the Bitterroot, *Lewisia rediviva*, in southwestern Alberta has been interpreted by its discoverers as a result of modern wind-assisted dispersal across the continental divide. This paper examines evidence that would support an alternative of cultural dispersal by native or non-native groups, and other evidence in support of natural dispersal by range expansion during intervals of xeric conditions in the Holocene. Both hypotheses withstand initial scrutiny, indicating that the wind-dispersal hypothesis should be used with caution. Resolution of the question of dispersal mechanism has broad implications for other species of the southwestern Alberta flora.

Key Words: Bitterroot, *Lewisia rediviva*, dispersal, paleoclimates, Blackfoot, Kutenai, ethnobotany.

The Bitterroot, *Lewisia rediviva*, is an edible plant of the intermontane west, its root having been an important foodstuff for native groups. Until recently its Canadian distribution was thought to be restricted to British Columbia, but a significant discovery at two adjacent localities west of Pincher Creek has added it to the Alberta Flora (Kuijt and Michener 1985). The localities are on ridges in the vicinity of Mt. Backus, 22 km west of Pincher Creek, each locality being characterized by a kilometre or so of “blowout” habitat in which *L. rediviva* occurs. Kuijt and Michener (1984: 266) present a reasonable argument for wind-assisted natural dispersal of the species into the area. The present paper discusses two alternatives: cultural dispersal by native or non-native groups, and dispersal during past xeric climatic episodes with development of a disjunct relict distribution as a result of climatic changes. While the interpretation of Kuijt and Michener is not rejected, the alternative explanations deserve careful consideration.

Distribution and Natural Dispersal

Kuijt and Michener (1985: 266) suggest that this is only the second occurrence of *L. rediviva* east of the continental divide, the other being in the Yellowstone Valley of Montana. The species certainly is more abundant west of the divide, but there are many occurrences east of the divide in Montana. Most of southwestern Montana, as far

west as the state border, is in fact east of the continental divide. Therefore, Daubenmire's (1975: 12) map shows some twenty occurrences east of the divide in Montana, several of them along the upper Missouri River and its tributaries. The map also shows occurrences east of the divide in Wyoming.

Of several records along the west side of the Missouri River valley from Three Forks to Helena, Montana, an important example is one of abundant *L. rediviva* at the Pilgrim archaeological site and its environs, in the Limestone Hills west of Townsend (Davis 1983; Davis et al. 1982). The site is 8 km west of the Missouri River, and present abundance of Bitterroot and Wild Parsley (*Musineon divaricatum*) supports the hypothesis that their harvest was a major determinant of the archaeological site's location (Aaberg 1983). This site is 100 km closer to the Alberta locality than is Yellowstone Valley, but it is still distant enough to leave the occurrences markedly disjunct.

Booth and Wright (1966: 53) show occurrences even closer, in Glacier, Teton, and Cascade counties. According to their preface, these records are supported by herbarium specimens at Montana State University (Bozeman); however, SAA visited this herbarium and was unable to locate any such specimens. We are aware of sight records from other counties well east of the divide but these remain to be substantiated by herbarium specimens. It is appropriate to ask whether the

observed distribution is a realistic portrayal or an artifact of discontinuous sampling. Bitterroot is difficult to detect except at the flowering season (Turney-High 1941: 33; Aaberg 1983: 283), and may have been overlooked in some areas unless excavations for identifiable root-stocks were undertaken. The present authors agree that the Alberta occurrence is disjunct from other east slope localities, but the gap may be considerably less than the 450 km between Pincher Creek and Townsend.

Kuijt and Michener (1985: 266) hypothesize that Bitterroot plants arrived in Alberta by wind dispersal of seed clusters. This is supported by the fact that the discovery area is the windiest zone of Alberta, and that the species is present to the west in intermontane valleys of southeastern British Columbia (Wasa, Elko and Roosville are cited as localities). Turney-High (1941: 33) observed that the arid lands around Fort Steele, British Columbia, "were ideal bitterroot country". It must be noted, however, that the high winds in southwestern Alberta are chinooks, whose speed increases on the *downslope* side of the Rocky Mountains. In order to transport seeds over the continental divide the winds would need to be strong enough in valleys to the west to entrain the clusters and carry them to significant altitudes, a topic worthy of further investigation.

Cultural Dispersal

The Evidence

Kuijt and Michener (1985: 266) acknowledge the importance of Bitterroot to Indians of the northwestern plains and intermontane west. After Johnston (1970, 1982) they cite its possible use by southern Alberta Blackfoot, but conclude that

... except for the small populations of Bitterroot herewith reported, the historical geographic range (as presented by Johnston 1982) of the Blackfoot tribe is outside the range of the Bitterroot. This discrepancy implies trade for the roots with other Indians to the west and/or south of the Blackfoot range, if the Blackfoot did indeed use the Bitterroot.

Several points for discussion emerge from this quote. First of all, use of Johnston's articles as sources of reliable Blackfoot ethnographic information has been disputed by Hellson and Gadd (1974) who provide a detailed Blackfoot ethnobotany. According to Hellson and Gadd (1974: 1), Johnston's earlier papers (1960, 1968) consisted of

... listings of plants and their medical and edible properties, as reported in the literature (not first hand). Mr. Johnston's work is highly suspect, for in checking, we find only a dozen of his 58 references

make specific mention in any detail of Blackfoot botanical use, the other references mention only generalized "Indian" uses. The reader should not be confused by the format of his title in which he commonly begins by citing only the Blackfoot name, many of which are mistranslated, and attributing uses which are reported by authors whose work had no Blackfoot content.

Hellson and Gadd (1974) conducted extensive interviews with Blackfoot informants and examined the contents of Blackfoot medicine bundles. They recorded no use of *Lewisia rediviva* among Alberta Blackfoot, but noted Ewers' (1955: 49) record of its use in a tonic for horses (Hellson and Gadd 1974: 92). Ewers' data came largely from northern Montana Blackfeet, as did accounts of other authors cited by Johnston (1968). McClintock (1910: 530) listed the plant as a root-stock food source for Montana Blackfeet. [Note that "Blackfoot" is Alberta usage; "Blackfeet" is Montana usage.] Widespread trade of Bitterroot from natives to French Canadian hunters and Northwest Company traders was noted by David Thompson in the early 19th century (Hart 1976: 47).

Kuijt and Michener's (1986) discussion of the "range" of the Blackfoot and the range of *L. rediviva* suggests their comparability. However, the Blackfoot were highly mobile equestrians who possessed guns at an early time and who travelled widely over the northwestern plains. Any tribal "range" that they might have had was, unlike that of a plant, an instantaneous response to pressures from neighbouring groups — most of them reacting in turn to displacement by white settlers (or other groups displaced by white settlers) to the east and south. Blackfoot were periodically present in Crowsnest Pass and well into Montana (e.g. McClintock 1910) and would have been familiar with areas in which Bitterroot plants were found. Blackfeet raiders periodically plundered the Flathead, Kalispell, Pend d'Oreille, Spokane, and Nez Perce Indians when these groups gathered near Missoula, Montana, each spring to dig the root (Hart 1976: 47). Blackfeet were the native group most frequently encountered by trappers in the Yellowstone area of Montana and Wyoming (Reeve 1980: 366).

All of this, however, overlooks the fact that there were other native groups in southwestern Alberta. For example, Kutenai and Flathead regularly moved back and forth across the continental divide from Alberta into Montana, Idaho, and British Columbia. British Columbia native groups knew how to prepare the Bitterroot, and this is certainly true of the Kutenai (Turney-High 1941: 33; Aaberg

1983: 285–288). Trade of the Bitterroot was recorded by Lewis and Clark as well as by David Thompson (Hart 1976: 47), and the dried root could be stored for at least one to two years.

The Kutenai pursued a seasonal round with summer hunting in the foothills east of the Rocky Mountains, and westward movement to the Flathead and Kootenay valleys in the winter (Turney-High 1941). This pattern was disrupted by Blackfoot raiding such that, by the mid-nineteenth century, trips to the Alberta foothills were limited to brief hunting and trading expeditions to put up winter stores (Driver 1978: 5–6). William Parker, a Northwest Mounted Policeman based in Fort Macleod, encountered a Kutenai group near Lundbreck Falls heading westward after a hunt in 1877. They had 600 horses packed with dried buffalo meat (Dempsey 1973: 131).

Here, then, was a group that frequented Bitterroot territory part of the year, and regularly passed the Alberta locality discovered by Kuijt and Michener (1985). The Kutenai used Crownsnest Pass but much preferred North Kootenay Pass, at the head of Carbondale River, and South Kootenay Pass, at the head of Blakiston Valley in what is today Waterton Lakes National Park. Mt. Backus lies close to North Kootenay Pass, the route used by the group encountered by Parker. Captain Thomas Blakiston, associated with the Palliser expedition, observed that North Kootenay Pass was used by horse-mounted groups; South Kootenay Pass was used for heavily loaded horses. Crownsnest Pass tended to be disdained, possibly because of heavy deadfall on the west side of the summit (Spry 1968: 565–580).

Southern Alberta native groups were acquainted with plant cultivation. For example, Native Tobacco (*Nicotiana multivalvis*) was planted and harvested by Northern Blackfoot Tobacco Society members for ceremonial use (Hellsen and Gadd 1974: 14). Earth lodge people who constructed a village near Cluny in the 1700s were affiliated in some way with horticultural groups along the middle Missouri River of North Dakota; they may well have tried to grow corn (Forbis 1977).

On this basis, it is plausible that the Kutenai or a similarly transhuman group such as the Flathead or Nez Perce could have introduced the Bitterroot from British Columbia, Idaho, or northwestern Montana into Alberta. Introduction could also have been at the hands of early white explorers, hunters, and traders, who participated freely in the Bitterroot trade (Hart 1976: 47). Introduction may have been by direct cultural agency, as by planting

or scattering of seed, or by passive agency, as by accidental discard of seeds carried with dried roots. Even the contention that propagation required seeds is open to question. The name *rediviva* commemorates the fact that the type specimen was resprouted from a dried root collected several years earlier by Meriwether Lewis and stored in a herbarium (Daubenmire 1975: 9; Hart 1976: 47). Another specimen was revived after having been boiled and pressed (Daubenmire 1975: 9). Seeds, therefore, were not necessary for establishment of the Alberta occurrence.

This is not only the area of highest annual wind speed in Alberta, but also the area with the most pronounced — and best documented — movements of native groups back and forth across the Canadian Rocky Mountains. Similar movements occurred not just through Crownsnest, North Kootenay and South Kootenay passes, but also southward across Flathead Pass from the Waterton Lakes area into Flathead Valley (Reeves 1974). Of interest is the presence in Waterton Lakes National Park of Blue Camas (*Camassia quamash*), a species restricted in distribution in Alberta but widespread west of the continental divide, where it was intensively harvested by native groups. Blue Camas was possibly introduced at Waterton by native groups passing through (Kuijt 1982: 395). Other occurrences in the Oldman basin are few and localized (Moss 1983: 630), consistent with human agency in introduction.

Other plant species of economic importance to native groups and of localized (though not necessarily disjunct) occurrence in southwestern Alberta include Yellow Angelica (*Angelica dawsonii*), Oregon grape (*Berberis repens*), Western Sweet Cicely (*Osmorhiza occidentalis*), and Yellow Paintbrush (*Castilleja cusickii*). *Angelica dawsonii* (“power root”) is of great interest because of its widespread importance among the Blackfoot in ceremonial contexts as well as its medicinal value (Hellsen and Gadd 1974: 40–47). Hellsen and Gadd encountered specimens regularly in the possession of informants and in medicine bundles, but did not find it in the field because of its extremely restricted distribution in Alberta. Widespread occurrence among Blackfoot could indicate that this was another traded species. *Berberis repens* and *Castilleja* spp. both had medicinal significance; berries were available from the former but the whole plant was used in the case of the latter. *Angelica dawsonii* roots and *Berberis repens* berries could have been carried into Alberta by native groups for planting or for accidental discard. Other species of *Castilleja* were wides-

pread in southern Alberta (Moss 1983: 654), so *C. cusickii* itself may not have had cultural significance. *Osmorhiza occidentalis* had a wide variety of medicinal, dietary, and disinfectant uses and was again a root crop.

Implications

Aaberg (1983) has documented the importance of *Lewisia rediviva* as a foodstuff. He suggests that at the Pilgrim Site, in Montana,

[the] unique factor . . . upon which prehistoric people may have keyed, is the presence of bitterroot in abundance along with . . . dense growths of wild parsley . . . [which] reach their most palatable condition at about the same time. The geologic and pedologic peculiarities at Pilgrim may have created an environment singularly conducive to the propagation of populations of both species, since neither these local conditions nor large, co-occurring colonies of the plants are apparent in other areas of the Limestone Hills examined (1983: 302).

The argument, then, is that people occupied the site because of the presence of these plants. Bitterroot could also have been there initially because of introduction by native groups. Archaeologists should search the Mt. Backus area near the newly documented occurrences for similar campsites. Location of the occurrences on rugged ridges would have been no deterrent to human occupation; windswept ridges were sought by native groups as ideal places to dry meat for storage, and ridges were used as lookouts for hunting and defense.

Localized, disjunct occurrences of plants that were economically important native groups therefore cannot be assessed fully without consideration of the possibility of cultural dispersal. Adventitious plantings of such species beyond their normal range would make economic sense in providing local supplies to supplement or even supplant long-distance trade, and to provide "wayside stops" along seasonal migration routes. Native use and trade would also have resulted in occasional accidental plantings. Such considerations are of extreme importance to archaeologists and phytogeographers because of the low level of visibility of plant-gathering cultural systems in the archaeological record. Isolated occurrences of possible digging tool fragments (Wilson 1983a), specialized roasting pits (Frison 1983), and occasional charred seeds are all that we usually expect to see on the northwestern plains; yet, from the richness and diversity of ethnobotanical accounts (Hellson and Gadd 1974; Johnston 1982; Hart 1976), there was much more going on than now meets the eye. Extralimital occurrences of

economic plants could well be the information we have been seeking.

Altitheermal Natural Dispersal

Discovery of the Bitterroot at such a seemingly isolated locality invites consideration of the possible role of Holocene environmental conditions in its dispersal. It is possible that these are not recently adventitious individuals but a relict occurrence of a formerly widespread species. Holocene climatic conditions have been sufficiently variable in the Crowsnest Pass area (Christensen and Hills 1985; Driver 1978; Driver, Hills, and Reeves 1985; Ferguson and Hills 1985) that this possibility merits serious consideration.

Of obvious relevance is the Hypsithermal (Altitheermal) climatic interval, which lasted from about 9000 to 5000 years ago, and a minor warming event between 4000 and 3000 years ago. During these intervals grasslands extended into areas earlier and later occupied by forests, both in the Alberta foothills and mountains and along the boreal forest/parkland boundary in central Alberta (Schweger, Habgood, and Hickman 1981). Lakes in central and northern Alberta shrank dramatically or dried up completely during the Hypsithermal (Schweger, Habgood, and Hickman 1981). Soil drifting occurred in southern Alberta, giving truncated profiles and locally thick aeolian deposits (e.g. Forbis 1968: 2). Rivers, overloaded with sediment of slopewash origin, aggraded through significant overbank deposition, a process that slowed markedly after phytostability returned to southern Alberta landscapes (Wilson 1983b). On the basis of such evidence it is clear that warmer and drier-than-modern conditions prevailed in Alberta (Buchner 1980). Forests migrated to higher elevations with grasslands extending westward into the pass and floras including Douglas Fir (*Pseudotsuga menziesii*) and xeric associates moving eastward through the pass.

Pollen records indicate that plant species and community boundaries migrated at least locally in response to Hypsithermal aridity and lesser aridity between 4000 and 3000 yr BP. Under such circumstances species favoring more xeric conditions likely migrated into Alberta. Crowsnest Pass would have been one conduit for such a migration from the dry East Kootenay intermontane region. The arrival of Bitterroot in Alberta by these means during the Hypsithermal is a distinct possibility.

Published occurrence maps for Alberta plants (Moss 1983; Packer and Bradley 1984) reveal that

TABLE 1. Plant species restricted to southwestern Alberta¹.

Scientific Name	Common Name	Habitat Type
<i>Adenocaulon bicolor</i>	Pathfinder; Trail-plant; Silver-green	moist
<i>Adiantum pedatum</i>	Maidenhair Fern	moist
<i>Angelica arguta</i>	White Angelica	moist
<i>Angelica dawsonii</i>	Yellow Angelica	moist
<i>Antennaria luzuloides</i>	Silvery Pussytoes; Everlasting	dry or moist
<i>Arabis nuttallii</i>	Nuttall's Rock Cress	moist
<i>Artemisia tridentata</i>	Big Sagebrush	dry
<i>Aster campestris</i>	Meadow Aster	dry
<i>Berberis repens</i>	Creeping Mahonia; Oregon Grape	dry
<i>Botrychium paradoxum</i>	Paradoxical Grape Fern	moist
<i>Brickellia grandiflora</i>	Large-flowered Brickellia	dry or moist
<i>Bromus vulgaris</i>	Mountain Brome	dry
<i>Bupleurum americanum</i>	Thoroughwax	moist
<i>Calochortus apiculatus</i>	Mariposa Lily	dry
<i>Camassia quamash</i>	Blue Camas	moist
<i>Carex epappilosa</i>	Sedge	...
<i>Carex geyeri</i>	Geyer's Sedge	dry
<i>Carex kelloggii</i>	Kellogg's Sedge	moist
<i>Carex mertensii</i>	Merten's Sedge	moist
<i>Carex paysonis</i>	Payson's Sedge	...
<i>Carex preslii</i>	Presl's Sedge	dry
<i>Carex vesicaria</i>	Blister Sedge	moist
<i>Castilleja cusickii</i>	Yellow Paint-brush	moist
<i>Ceanothus velutinus</i>	Snow-brush; Deer Brush; Buckbrush; Sticky Laurel	dry
<i>Cheilanthes gracillima</i>	Lace Fern	...
<i>Cirsium scariosum</i>	Thistle	moist
<i>Conimitella williamsii</i>	Williams' Conimitella	moist
<i>Cypripedium montanum</i>	Mountain Lady's-slipper	moist
<i>Disporum hookeri</i>	Oregon Fairy-bells; Hooker's Fairy-bells	moist
<i>Douglasia montana</i>	Mountain Dwarf-primrose	...
<i>Draba densifolia</i>	Dense-leaved Whitlow Grass	...
<i>Dryopteris filix-mas</i>	Male Fern	moist
<i>Epilobium glaberrimum</i>	Willowherb	moist
<i>Epilobium mirabile</i>	Willowherb	dry
<i>Erigeron divergens</i>	Spreading Fleabane	dry
<i>Festuca subulata</i>	Bearded Fescue	moist
<i>Galium bifolium</i>	Two-leaved Bedstraw	dry or moist
<i>Gayophytum racemosum</i>	Low Willowherb; Groundsmoke	dry or moist
<i>Gentiana calycosa</i>	Mountain Gentian	moist
<i>Glyceria elata</i>	Tall Manna Grass	moist
<i>Gnaphalium microcephalum</i>	Tall Cudweed	dry
<i>Gnaphalium viscosum</i>	Clammy Cudweed	dry
<i>Habenaria saccata</i>	Slender Bog Orchid	moist
<i>Hydrophyllum capitatum</i>	Woollen-breches	moist
<i>Hypericum formosum</i>	Western St. John's-wort	moist
<i>Iliamna rivularis</i>	Wild or Mountain Hollyhock	dry
<i>Isoetes bolanderi</i>	Bolander's Quillwort	moist
<i>Lewisia pygmaea</i>	Dwarf Bitterroot	moist
<i>Lewisia rediviva</i>	Bitterroot	dry
<i>Listera convallarioides</i>	Broad-lipped Twayblade	moist
<i>Matium sandbergii</i>	Sandberg's Wild Parsley	dry
<i>Lonicera utahensis</i>	Red Twin-berry	moist
<i>Luzula hitchcockii</i> (? <i>glabrata</i>)	Hitchcock's Woodrush; Smooth Woodrush	...
<i>Machaeranthera tanacetifolia</i>	Tansy-leaved Aster	dry
<i>Melica smithii</i>	Melic Grass	moist
<i>Melica subulata</i>	Alaska Onion Grass	moist

continued

TABLE 1. (concluded)

Scientific Name	Common Name	Habitat Type
<i>Mertensia longiflora</i>	Trumpet or Large-flowered Lungwort	dry
<i>Microseris nutans</i>	Nodding Microseris; Scorzonella	moist
<i>Microseris gracilis</i>	Microseris	dry or moist
<i>Mimulus floribundus</i>	Many-flowered Monkey-flower	moist
<i>Minuartia nuttallii</i>	Nuttall's Sandwort	dry
<i>Montia parvifolia</i>	Small-leaved Spring Beauty; Little-leaf Montia	moist
<i>Nemophila breviflora</i>	Great Basin Nemophila; Small Baby Blue-eyes	moist
<i>Oryzopsis exigua</i>	Little Rice Grass	dry
<i>Osmorhiza occidentalis</i>	Western Sweet Cicely	moist
<i>Pachistima myrsinites</i>	Mountain Lover; Mountain Box	...
<i>Papaver pygmaeum</i>	Dwarf Alpine Poppy	dry
<i>Penstemon eriantherus</i>	Crested Beard-tongue	dry
<i>Phacelia hastata</i>	Silver-leaf Scorpion Weed; Phacelia	dry
<i>Phacelia linearis</i>	Narrow-leaf Scorpion Weed; Phacelia	dry
<i>Phacelia lyallii</i>	Lyall's Scorpion Weed; Phacelia	dry
<i>Philadelphus lewisii</i>	Mock Orange; Syringa	moist
<i>Physocarpus malvaceus</i>	Mallow-leaved Ninebark	...
<i>Pinus monticola</i>	Western White Pine	moist
<i>Poa gracillima</i>	Pacific Bluegrass	moist
<i>Polygonum engelmannii</i>	Slender Knotweed	dry or moist
<i>Polygonum minimum</i>	Least Knotweed	dry
<i>Polypodium hesperium</i>	Rocky Mountain Polypody	moist
<i>Prenanthes</i>	Wing-leaved Rattlesnake-root	moist
<i>Puccinellia pauciflora</i>	Small-flowered Manna Grass	moist
<i>Pyrola bracteata</i>	Pink or Large Wintergreen	moist
<i>Pyrola picta</i>	White-veined Wintergreen	...
<i>Ribes laxiflorum</i>	Trailing Black Currant	moist
<i>Ribes viscosissimum</i>	Sticky Currant	dry or moist
<i>Saussurea americana</i>	Tall Saw-wort	moist
<i>Saxifraga mertensiana</i>	Merten's Saxifrage	moist
<i>Saxifraga oregana</i>	Oregon Saxifrage	moist
<i>Saxifraga odontoloma</i>	Washington Saxifrage	moist
<i>Sedum stenopetalum</i>	Common Stonecrop; Douglas Stonecrop	dry
<i>Selaginella wallacei</i>	Wallace's Little Club-moss	dry
<i>Senecio cymbalarioides</i>	Alpine Groundsel	dry or moist
<i>Senecio megacephalus</i>	Large-flowered Ragwort	...
<i>Spiraea densiflora</i>	Pink Meadowsweet	moist
<i>Stellaria americana</i>	Alpine Chickweed; Starwort	dry
<i>Stellaria obtusa</i>	Meadow Chickweed	moist
<i>Suksdorfia ranunculifolia</i>	White Suksdorfia	moist
<i>Suksdorfia violacea</i>	Violet or Blue Suksdorfia	moist
<i>Taxus brevifolia</i>	Western Yew	moist
<i>Townsendia condensata</i>	Townsendia	dry
<i>Trillium ovatum</i>	Western Wake-robin; Western White Trillium	moist
<i>Trisetum canescens</i>	Tall Trisetum	moist
<i>Trisetum cernuum</i>	Nodding Trisetum	moist
<i>Viola macloskeyi</i>	MacLoskey's Violet	moist
<i>Xerophyllum tenax</i>	Bear-grass	dry

¹After Cormack (1977), Kuijt (1982), Moss (1983), Packer and Bradley (1984), and Scoggan (1978-1979). Where habitat type was not characterized in terms of moisture, habitat column is left unfilled.

there are many species which are today restricted to the extreme southwestern corner of the province (Table 1). Included are species restricted to western North America and others much more widespread; however, the fact that they co-occur in a restricted

area of Alberta suggests that some may have shared a common dispersal history, at least on a local scale. Among these are additional species that were of economic importance to native populations, but this does not characterize all of them. Based on habitat

descriptions in Cormack (1977), Scoggan (1978–1979), Kuijt (1982), Moss (1983) and Packer and Bradley (1984), thirty favor dry sites, fifty-six favor moist sites, and eighteen are of intermediate character or uncertain reference. Including *Lewisia rediviva*, we therefore have at least 30 species that could have arrived during earlier Holocene warm/dry intervals by migration from the west. As climates subsequently cooled and tree-line was lowered, the eastern grasslands would have retreated eastward, whereas the vegetation from the interior would have been eliminated from the higher parts of the pass. This would have left disjunct populations at the eastern end of the pass. As climates cooled the plants would have subsequently been restricted even further to more favorable areas in the vicinity of the pass; in the case of *L. rediviva* this could well explain the localized occurrences documented by Kuijt and Michener (1986). However, the great variety of habitat types for the species in Table 1 indicates that they could not all have dispersed together; the reasons for their arrival and restriction in Alberta are complex.

Pollen studies from local bogs concentrate upon certain key indicator species and tell us little about many species considered here. However, the overall paleoenvironmental sequence in the mountains and foothills, including evidence for periods of aridity, is clear (Vance 1985). Evidence from Manitoba suggests that summer mean temperature was up to 3°C warmer than today during the Hypsithermal (Ritchie 1983: 166–168). As yet, adequate pollen sequences have not been found on the open southern Alberta plains, where most if not all ponds, lakes and sloughs dried up periodically and underwent ablation of their deposits by wind action. Such truncation of deposits would have been most marked at the precise time of the plant migrations discussed here.

Concluding Remarks

Modern disjunct plant distributions can result from a variety of factors, both cultural and natural. It is not possible to evaluate the disjunct occurrence of a species such as *Lewisia rediviva* without giving equal attention to the possibility of modern natural dispersal, cultural dispersal (intentional or accidental), and past climatic change. Indeed, there always remains the possibility of “rafting” on other natural vectors such as birds’ feet (in clinging mud), or via passage through the digestive systems of birds. These possibilities we view as less likely, but again not impossible, in the present case.

Within the array of possibilities presented here, there remains much room for disagreement. Indeed, the present authors differ among themselves in preference, with Wilson, Reeves and Aaberg favoring cultural dispersal and Hills favoring Hypsithermal natural dispersal. Resolution of these

disagreements will rest in more adequate documentation of the natural range of *L. rediviva* today, the recognition of distinctive palynomorphs and a search for fossil pollen, and the possible recovery of plant macrofossils (for example, in a dry cave where they could have been placed by humans). For this species, the search for adequate information will be difficult. Reeve (1980) has encountered similar difficulties in assessing cultural vs. natural dispersal in terms of the modern flora of the Yellowstone National Park area of Wyoming. Clearly, these questions are of more than local interest, and their ultimate resolution will be of great significance in terms of the phytogeography of western North America.

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Distribution of the Showy Aster, *Aster conspicuus*

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The geographical distribution and habitat of the Showy Aster, *Aster conspicuus* Lindl., were determined from herbarium collections. *Aster conspicuus* has a Middle Cordilleran and Western Boreal North American distributional pattern. Different environmental limiting factors appear to control the present distributional limits of the species. The species has the ability to survive and to spread vegetatively beneath closed forest canopies by means of slender underground rhizomes. It then flowers profusely upon removal of overhead shade by fire or other clearing agencies.

Key Words: Showy Aster, *Aster conspicuus*, phytogeography.

A study of the distribution and ecology of *Aster conspicuus* was initiated to clarify its range and to ascertain the various ecological and paleohistorical factors that have affected its present distribution. *A. conspicuus* is a very distinctive species in its genus, a feature perhaps related to its unusually high ploidy level, reported as $2n = 112$ (Semple et al. 1983). Because this species is not readily confused with any other species of *Aster*, xerographic copies were obtained from many of the university herbaria and from some private collections in the northwestern United States and adjacent Canada (including ALTA, FQH, IDS, ORE, RM, SASK, SDU, USAS, V, WAT, WIN: acronyms according to Holmgren et al. 1981). From these, the species' distribution was determined and a dot map (Figure 1) was compiled.

Aster conspicuus has a Cordilleran and Western Boreal distribution, ranging from central British Columbia (Skeena and Peace rivers), northern Alberta (along the Peace River), northwestern (Clearwater River) and central Saskatchewan to The Pas, Manitoba, south through the Cascade and Rocky mountains to central Washington, east-central Oregon, central Idaho, northern Wyoming and the Black Hills of Wyoming and South Dakota (see Figure 1).

Ecologically, *A. conspicuus* appears to be restricted to relatively narrow ranges of climate, soil and forest associations. The species occurs in mesic woodlands on glacial till composed of yellow clay and boulders of various sizes and most often on north-facing slopes. It occurs in almost all associations of mesic, more or less open, coniferous and mixed-wood (mainly aspen-coniferous) forests within its range, but is largely absent in very wet (e.g. Black Spruce, *Picea mariana*) and quite dry (e.g. some pine) forests. It

also sometimes occurs in pure aspen stands of both the northern parklands and western mountains. According to Peter F. Stickney (personal communication), *A. conspicuus* was present in 434 or 29% of 1482 stands he sampled in western Montana montane and subalpine climax forests.

Of special interest is the ability of *A. conspicuus* to maintain and extend itself by means of spreading underground rhizomes in sterile or vegetative condition under a closed forest canopy. With the removal of overshadowing tree crowns by fire or other clearing agencies, *A. conspicuus* responds with profuse flowering. Rhizomes surviving early spring forest fires soon send up vigorous spring growth, often forming luxuriant masses of bloom by late summer. In this ability to respond to forest fires, *A. conspicuus* is similar to the ubiquitous Fireweed, *Epilobium angustifolium* (Moss 1955: 524).

Climate and soil appear to be the chief limiting factors controlling the present distribution of the species. On the western perimeter, the species seems to be inhibited from occurring in the dense wet Pacific Coast coniferous forests by excessive moisture from the Pacific Ocean. In contrast, along the southern perimeter, the climate appears too xeric for a further southward migration of the species. In northern British Columbia and adjacent Alberta, the growing season is probably too short for the seed maturation of this late-flowering species, and thus restricts its further northward or northwestward migration.

The northern or northeastern distributional limit of *A. conspicuus* follows a crescentic line approximately parallel to, and mostly about 80 miles south of, the southern boundary of the Canadian Precambrian Shield, with its eastern terminus at The Pas, Manitoba (Krivda 1984). The fact that *A. conspicuus* and a number of other

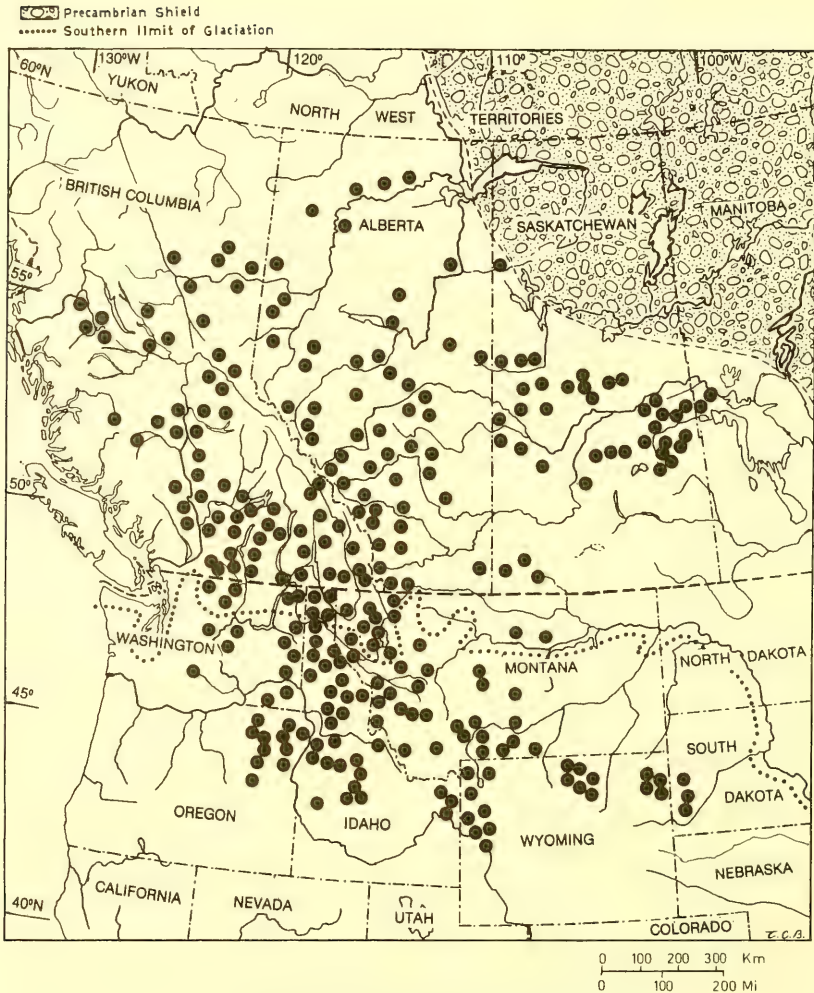


FIGURE 1. Distribution of the Snowy Aster, *Aster conspicuus*.

plant species relatively common in the boreal forest belt just south of the Precambrian Shield are absent from the Shield flora indicates that the Shield is a likely barrier to their northward migration. John H. Hudson (personal communication) suggested the plausible explanation that *A. conspicuus* may require a certain amount of Cretaceous shale or other bentonitic clay in the soil and it is only at a certain distance from the acidic Precambrian rocks that the glacial mixing action ensures that the till includes enough ground-up Cretaceous materials. The northern limit of *A. conspicuus* may also be related, at least in part, to the summer (July) isotherm line of 60° F [= ca. 16° C] (Donn 1975).

At its eastern range extremities, the denser and moister mixed-wood and deciduous forests, numerous bogs, large lakes, and the lowlands of former post-glacial Lake Agassiz appear to have prevented the further eastward migration of *A. conspicuus*.

In Saskatchewan, north of the grassland plains, *A. conspicuus* occurs in the northern Aspen Parkland and southern (Mixed-wood Section) Boreal Forest zones, largely within the Saskatchewan River drainage and those of the more southern Churchill River tributaries. Interestingly, at approximately 52°N latitude in east-central Saskatchewan, the headwaters of the Red Deer

River, draining northward, and those of the Assiniboine River, flowing southward, are found in close proximity, sometimes less than 1 km (about one half mile) apart in places. But, while *A. conspicuus* occurs near the sources of the Red Deer River, it has not crossed over into the Assiniboine drainage.

During the Pleistocene glacial advances, *A. conspicuus* probably survived mainly in refugia south of the limit of glaciation in the northwestern United States, and to some extent perhaps in ice-free areas farther north in British Columbia. Thompson (1953: 116) suggests that the "Glaciation in the Rocky Mountains (probably) consisted of a series of relatively distinct glaciers rather than a continuous ice cap". Hence, there may have been opportunity for *A. conspicuus* to remain in these areas through the glacial period.

According to Hult n (1968), based on Hopkins (1967), it is postulated that a flora (which might have included *A. conspicuus*) also survived in the hypothetical ice-free corridor between the Cordilleran ice front and that of the Keewatin ice sheet in western Alberta. As the glaciers waned and the corridor widened, *A. conspicuus* presumably migrated both eastward and westward, colonizing the favourable mesic habitats within the also expanding forest ecosystem.

It is unknown how far *A. conspicuus* may have formerly ranged eastward across the Interior Great Plains during the cool moist period about 13 000 to 9500 years ago when a continuous coniferous forest presumably stretched across this region south of the receding Wisconsin Continental Ice Sheet. As the glaciers receded northeastward, the forest belt followed. Eventually, with the amelioration of the climate on the Great Plains from a cool moist to a warmer and then drier type, the forest was gradually replaced by the present grassland (Borchert 1950; Breitung 1954; Love 1959; Ritchie 1966, 1976).

Due to their local retention of cooler and moister climates, the Black Hills of South Dakota and adjacent Wyoming, the Canadian Cypress Hills, and other elevated sites in Montana and Wyoming east of the Rocky Mountains still support a rich flora, including a mixture of Rocky Mountain forest, alpine, and wide-ranging circumboreal species. The flora of these wooded hills now surrounded by grasslands is the remnant of a formerly wide-ranging forest flora on the Great Plains (Borchert 1950).

During the cool, moist post-glacial period, when coniferous forests extended across the Great Plains at least as far southward as South Dakota,

associated plant species, such as the now disjunct Thimble-berry (*Rubus parviflorus*) and Black Hawthorn (*Crataegus douglasii*), may have had a continuous distribution. They may also have migrated eastward, or their seeds may have been carried long distances by birds to the Upper Great Lakes region where these species have persisted as relicts separated from the species' main western ranges by the vast grassland plains of the present (Fassett 1941: 30, 346).

Thompson and Kuijt (1976) listed a number of Cordilleran plant species occurring in the Sweet Grass Hills of northern Montana that are not found in the Cypress Hills of Canada, including the important trees, *Abies lasiocarpa*, *Pinus albicaulis*, *Pinus flexilis*, and *Pseudotsuga menziesii*. For some undetermined reason, *Aster conspicuus* appears to be absent from the Sweet Grass Hills flora, although, according to L. W. Hagenner (personal communication), it does occur in the Little Rockies and Bear Paw Mountains of Montana, south of the Cypress Hills.

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Notes

Evidence of Autumnal Harbour Seal, *Phoca vitulina*, Movement from Canada to the United States

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Rosenfeld, M., M. George, and J. M. Terhune. 1988. Evidence of autumnal Harbour Seal, *Phoca vitulina*, movement from Canada to the United States. *Canadian Field-Naturalist* 102(3): 527-529.

Harbour Seals, *Phoca vitulina concolor*, in the Bay of Fundy, New Brunswick, may move to New England during the autumn. Aerial counts of seals on haul-out sites along the Bay of Fundy coast revealed a linear decrease in numbers (75%) from mid-October to mid-December. A simultaneous, linear increase of the same order of magnitude was observed at the southern end of their range in New England.

Key Words: Harbour Seal, *Phoca vitulina*, movement, Bay of Fundy, New England.

Harbour Seals, *Phoca vitulina concolor*, have been described as non-migratory (Mansfield 1967; Bigg 1981). However, Gilbert and Wynne (1984) report that pups tagged in Nova Scotia and Maine have been resighted in southern New England. Observations of Harbour Seal numbers on haul-out sites in the Bay of Fundy indicate an annual decrease in numbers during the autumn and winter (Terhune and Almon 1983; Terhune 1985). Harbour Seals at the southern end of their breeding range (southern Maine) increased three to five times at 19 year-round sites during the winter of 1983-84. Seals were also recorded appearing at nine wintering sites along the New Hampshire and northern Massachusetts coast during the same period (Rosenfeld and George, unpublished data). Schneider and Payne (1983) report that Harbour Seals occur seasonally at Stage Point, Massachusetts (41°55'N, 70°32'W) from late October through May.

This suggests that a general southward movement of Harbour Seals along the Bay of Fundy-New England coast may be occurring during the autumn and early winter. We conducted independent aerial surveys over the northern and southern ends of this region during this time period. The numbers and rates of departures and arrivals in these areas support the hypothesis of an annual southward movement by Harbour Seals during autumn and early winter.

Methods

The southern aerial surveys were conducted over approximately 140 km of the New England coast. The flight path began at islands off Cape Ann, Gloucester, Massachusetts (42°37'N, 70°36'W), and continued northward to Cape Elizabeth, Portland, Maine (43°42'N, 70°18'W). All islands and shoals up to 8 km offshore were surveyed. The northern aerial surveys covered the coastline and adjacent nearshore islands in the Bay of Fundy between Saint John, New Brunswick (45°18'N, 66°20'W), and the Maine border (44°50'N, 67°0'W). The Wolves and Grand Manan islands were not surveyed. Approximately 150 km of shoreline were surveyed.

The southern flights were conducted in a highwing Cessna 172 or 182 single-engine aircraft. There were two or three experienced observers in addition to the pilot. Flights were timed so that the first haul-out sites were surveyed two hours before low tide. Surveys were conducted under conditions favourable for haul-out (good visibility, winds under 32 km/hr, waves 1 m or less, wind-chill corrected temperatures above -12°C (see Boulva and McLaren 1979). Ledges were searched at an altitude of 100-260 m. Groups of more than five seals were photographed using 35-mm cameras with 200 or 85 mm lenses.

The northern flights were similar except that the wind-chill corrected temperatures were all above

-1°C, counts began 1.5 hours before low tide, counts were conducted at a lower altitude (50–100 m) and only large groups of seals were photographed. One group entered the water before it could be counted or photographed. This group was estimated at 100 seals (30 October 1984).

Results

Flight dates (August to January) and numbers of seals seen for both sets of surveys are shown in Figure 1. The data were examined to determine whether the departures and arrivals were occurring at a linear rate (Terhune 1985). To compare the rates of emigration from the north and immigration to the south (Figure 1), the northern data were inverted using the formula $Y = 238 + (979 - Z)$, where Y is the inverted number of seals and Z is the number actually sighted per survey (maximum = 979, minimum = 238). The equation for the northern 1984 inverted data (as plotted in Figure 1) is $Y = 197.8 + 11.6X$ where X is the survey date (first date = 0). The correlation coefficient ($R = 0.98$) is significant ($F = 21.7$, $P < 0.01$). The equation for the southern 1983 data (Figure 1) is $Y = 179.0 + 8.5X$ ($r = 0.99$, $F = 33.2$, $P < 0.01$). The southern 1984 data do not correlate with a straight line ($r = 0.92$, $F = 5.2$, $P > 0.05$).

The overall changes in numbers and the rates of change per day are presented in Table 1. The southern data presented include the survey dates immediately prior to and following the northern 1984 survey period.

Discussion

Although the northern and southern surveys were conducted independently, they shared many similar features. The differences in methodology mentioned above are not thought to be significant.

The linear nature of the decrease in seal numbers (as opposed to a rapid, short-duration exodus) on

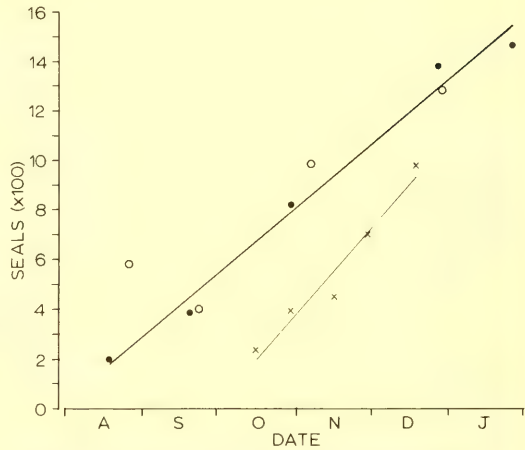


FIGURE 1. Changes in numbers of Harbour Seals on haul-out sites during autumn in the southern New England region (solid circles, 1983; open circles, 1984) and in the Bay of Fundy (Xs, 1984, inverted data, see text). The straight line equation for the southern 1983 data (heavy line) is $Y = 179.0 + 8.5X$. The equation for the Bay of Fundy 1984 data (thin line) is $Y = 197.8 + 11.6X$. For both equations, for the first day of each survey, $X = 0$.

haul-out sites in the Bay of Fundy has previously been reported (Terhune 1985). The linear increase in numbers of seals in 1983 in New England supports this observation. Although the southern 1984 data differ significantly from fitting a straight line, the data points follow the same trend as those of the previous year (Figure 1).

The absolute numbers of seals leaving and entering the two areas, both per season and per day, are very similar (Table 1). The greater number of seals arriving in the south is probably due to animals also arriving from Maine (Gilbert and

TABLE 1. Changes in Harbour Seal numbers at the northern and southern ends of their distribution along the Bay of Fundy–New England coast during autumn. The numbers in brackets substitute a higher count obtained on 27 August 1984 for that obtained on 24 September 1984 (see Figure 1).

Area	Survey Period	No. of Days	Changes in Seal Numbers	
			per Period	per Day
South	20 September — 28 December 1983	99	995	10.1
South	24 September — 30 December 1984	97	879 (697)	9.1 (7.2)
North	17 October — 19 December 1984	63	–741	–11.8

Wynne 1984), the Grand Manan Island area, and Nova Scotia. The inverse nature of these numerical changes suggests a southward movement in the autumn.

A few Harbour Seals do, however, remain in the Deer Island, New Brunswick, area throughout the winter (Terhune and Almon 1983). Tagging or tracking studies will be required to confirm the movements and ascertain which individuals or groups are remaining behind.

Movements of Harbour Seal populations — pups (Gilbert and Wynne 1984) as well as adults — must be considered prior to formulating management plans for this species. Population control programs intended to reduce Harbour Seal interference with commercial fisheries (Mansfield 1967) could be severely hampered by such movements. The movement of Bay of Fundy seals into waters off New England would also require international co-operation to properly protect or manage this species.

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Lesser Snow Geese, *Anser c. caerulescens*, Nesting on Jenny Lind Island, Northwest Territories

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McCormick, Kevin J., and Bert Poston. 1988. Lesser Snow Geese, *Anser c. caerulescens*, nesting on Jenny Lind Island, Northwest Territories. *Canadian Field-Naturalist* 102(3): 530–532.

An aerial survey in 1985 of Jenny Lind Island revealed approximately 54 000 (+ 17%, 95% C.L.) nesting Lesser Snow Geese (*Anser c. caerulescens*) on the island. Evidence suggests that this colony has undergone rapid growth.

Key Words: Lesser Snow Goose, *Anser c. caerulescens*, Jenny Lind Island, population growth.

Numbers of Lesser Snow Geese, *Anser c. caerulescens*, nesting in the western (Kendall Island, Anderson River, Banks Island) and central (Queen Maud Gulf) Canadian Arctic have increased during the last twenty years. Limited data indicate that the western Arctic population increased between 1952 and 1976, with a further 22% increase during the 1976–1981 period (Kerbes 1983, 1986). Numbers of breeding Lesser Snow Geese in the central Arctic increased five-fold between the mid 1960s and 1976 (Ryder 1969, 1971; Kerbes et al. 1983). The increase has continued: nearly double the 1976 total (56 000 breeding birds) was recorded in 1982 (106 000 breeding birds; Kerbes, R. H. 1984. Inventory of Ross' and Lesser Snow Geese nesting in the central Arctic, June 1982. Unpublished Report, Canadian Wildlife Service, Saskatoon. 39 pp.). Immigration, particularly from the west Hudson Bay colonies, may have contributed to that growth (McLaren and McLaren 1982; R. Kerbes, personal communication).

The Canadian Wildlife Service has recently compiled a list of the major bird sites in the Northwest Territories (K. J. McCormick, M. E. Adams, C. J. Stephenson, and A. S. Goodman. 1984. Key migratory bird terrestrial habitat sites in the Northwest Territories. Unpublished Report, Canadian Wildlife Service, Yellowknife. 175 pp.) Any site which supported at least one percent of the Canadian population of a migratory bird species or subspecies for any portion of the year was considered to be a key habitat site. Additional potential sites are being surveyed. This paper reports a 1985 aerial survey of Jenny Lind Island, N.W.T.

Study Area

Jenny Lind Island (68°43'N, 101°58'W) is situated southeast of Victoria Island (Figure 1).

The island, which is not more than 32 km across in any direction, has an area of approximately 420 km². It is generally flat with a few rocky ridges in its northern areas. Maximum elevation is less than 80 m. As a result, it is exposed to chilling winds that blow almost continuously across Queen Maud Gulf or down Victoria Strait (Parmalee et al. 1967). Sparse vegetation occurs on the ridge crests but lush sedge meadows characterize low-lying areas and wetlands in the central area of the island. Much of the southeast portion is sandy and barren. The south and east coasts are primarily sand, whereas the north and west coasts are composed of gravel and rocks.

Methods

Our survey, on 9 July 1985, was flown in a Bell 206-B helicopter at approximately 30 m agl (above ground level) and 125 k/h. Flight lines were delineated on 1:50 000 topographic maps so that data were recorded in three-km units along north-south transects spaced at two-km intervals (Figure 2). Visual markers were placed on the helicopter windows to delineate a 200-m transect on either side of the aircraft. The 400-m-wide survey route covered approximately 20 percent of the island. A navigator occupied the left front seat and two observers were in the rear seats. All observations were tape-recorded and later summarized.

Results

A total of 10 837 Lesser Snow Geese was counted on the transects. Because the survey was conducted after the young had hatched, pairs with young had dispersed from the breeding colonies and were scattered over the entire island with the exception of the southeast portion (Figure 2), which had limited vegetation. The main concentrations occurred in the central low-lying portions of the island, which support extensive sedge

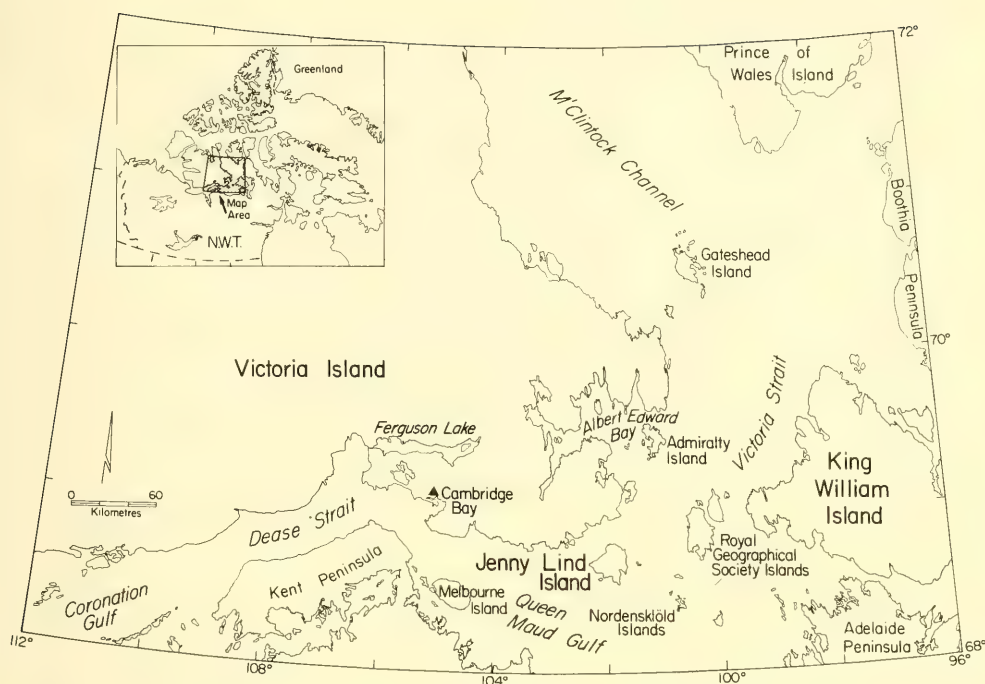


FIGURE 1. Location of Jenny Lind Island within the Northwest Territories.

meadows. The tendency of geese to flock when they heard our helicopter precluded the separation of non-breeding from breeding birds.

Of the 6584 birds whose colour was noted, 891 or approximately 13 percent were blue-phase birds.

Discussion

The historical numbers of Lesser Snow Geese on Jenny Lind Island are poorly known. Parmalee et al. (1967) visited the island in June–July 1962 and 1966, and based on extensive ground coverage of the eastern third of the island, estimated 200 birds. In 1971 558 birds of both blue and white colour phases were observed during approximately 58 km of survey (Kuyt, E., C. H. Schroeder, and A. R. Brazda. 1971. Aerial waterfowl survey, Queen Maud Gulf, N.W.T.; July–August 1971. Unpublished Report, Canadian Wildlife Service, Edmonton. 33 pp.). R. Decker (GNWT Department of Renewable Resources) surveyed the island in July 1982 and estimated that 3000 to 4000 birds were present.

Since the 1985 survey indicated there were 10 837 birds, the extrapolated total population on the island was about 54 000 birds ($\pm 17\%$, 95%

confidence limits) (Kerbes 1975). It was not possible to determine the proportion of non-breeding birds. No Ross' Geese (*Anser rossii*) were observed despite the proximity to colonies in the Queen Maud Gulf Bird Sanctuary.

A tremendous increase in Lesser Snow Goose numbers has apparently occurred during the last few years. It is unlikely that the apparent 12- to 15-fold increase resulted from local reproduction. Some immigration has probably occurred, although the origin of the birds is unknown. The Queen Maud Gulf and west Hudson Bay colonies are likely sources. Numbers in the latter area have declined significantly due to apparent overgrazing of preferred coastal sedge habitats (Kerbes 1982).

This colony adds substantially to the known Lesser Snow Goose population in the central Arctic. Present numbers represent over three percent of the Canadian population of this species. Jenny Lind Island is clearly a major migratory bird site in the Northwest Territories.

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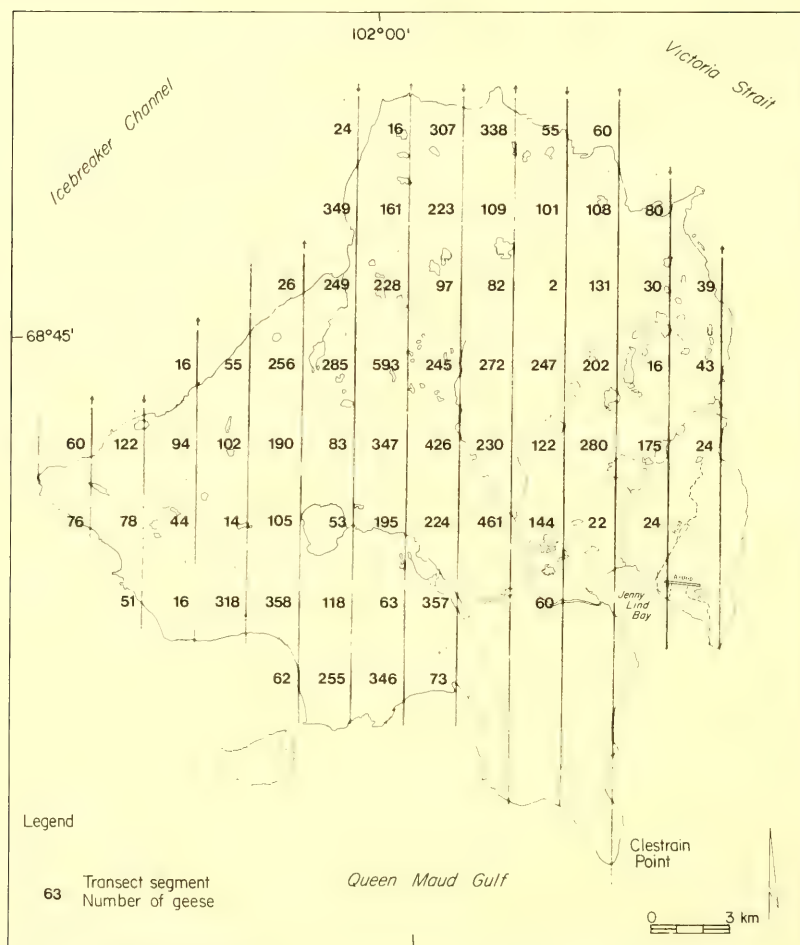


FIGURE 2. Distribution of Lesser Snow Geese on Jenny Lind Island, July 1985.

from the Polar Continental Shelf Project are gratefully acknowledged. Anne Gunn assisted with the survey.

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The Redfin Shiner, *Notropis umbratilis*, in the Middle Thames River, Ontario, and its Association with Breeding Longear Sunfish, *Lepomis megalotis*

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Noltie, D. B., and R. J. F. Smith. 1988. The Redfin Shiner, *Notropis umbratilis*, in the Middle Thames River, Ontario, and its association with breeding Longear Sunfish, *Lepomis megalotis*. Canadian Field-Naturalist 102(3): 533-535.

A population of Redfin Shiners (*Notropis umbratilis*) is reported from the Middle Thames River, Oxford County, Ontario. The habitat at the collection site is similar to that reported for the species from the centre of its range in North America. Redfin Shiner populations in the middle Thames appear breed early enough to form associations with the Longear Sunfish (*Leopmis megalotis peltastes*) and with other sunfish. Museum collections and Ontario Ministry of Natural Resources survey records reveal that the species' distribution in Ontario is more widespread than reported.

Key Words: Redfin Shiner, *Notropis umbratilis*, distribution, Ontario, habitat, breeding, interspecific brood care, Longear Sunfish, *Lepomis megalotis peltastes*.

Published records of the Redfin Shiner, *Notropis umbratilis*, document the species' occurrence in Canada for only eight locations, all in southern Ontario: Black Creek, Norfolk County; the Thames River, Essex and Oxford Counties; the Sydenham River, Middlesex County; the Ausable River, Lambton County; the Saugeen River, Bruce County; and Hepworth (= Mountain) Lake, Grey County (Hubbs and Brown 1929; Scott and Crossman 1973; Lee et al. 1980; Harvey 1981). This paper reports a 20 km range extension for the species, maps its Ontario distribution based on previously unpublished collections, and records its possible breeding association with the Longear Sunfish, *Lepomis megalotis peltastes*.

On 26 June 1985, while seeking breeding Longear Sunfish in the Middle Thames River (43°04'12" N; 81°00'16" W, Oxford County) 2 km north of Thamesford, Ontario, our attention was drawn to conspicuous shiners bearing bright red fins. Specimens were captured by seine and lift net.

The male shiners were bluish-green dorsally and all their fins were bright red. Males bore small, pointed nuptial tubercles on their chins and snouts. These tubercles extended along the tops of their heads and mid-dorsally to, and included, their first small dorsal rays. The females were gravid with free-flowing eggs, were less brightly coloured, and lacked tubercles. Both sexes lacked nuptial tubercles on their opercula, and most specimens lacked melanophores on the skin overlying their suprapectoral cleithra, in agree-

ment with descriptions of the Northern Redfin Shiner, *Notropis umbratilis cyanocephalus*, in Snelson and Pflieger (1975). Five voucher specimens submitted to the National Museum of Natural Sciences (NMC85-0604) were confirmed as this subspecies by D. E. McAllister.

A further sample of six males averaged 6.1 cm F. L. (fork length; S. D. = 0.3) and 3.388 g total weight (S. D. = 0.518), while five additional females averaged 5.5 cm F. L. (S. D. = 0.4) and 2.326 g (S. D. = 0.356). The mean gonadosomatic index (gonad weight as a percentage of total weight) was 1.040% (S. D. = 0.283) for males and 19.318% (S. D. = 1.080) for females, indicating breeding condition. These specimens were sectioned for subsequent histological examinations.

The habitat at our Middle Thames River collection site has been described by Keenleyside (1972, 1978), Bietz (1981), Salmon and Green (1983), Dupuis (1985), and Noltie and Keenleyside (1986). The river here is of low gradient, slow flowing, is typically clear except after heavy rains, and has a predominantly gravel and sand-silt bottom. Adjacent areas have thick growths of rooted aquatic macrophytes. Bank vegetation is composed of clumps of Sandbar Willow (*Salix interior*). Riffles occur a few hundred meters upstream from the collection site. Such habitat resembles typical Redfin Shiner habitat at the core of the species' range in North America (Hubbs and Lagler 1958; Scott and Crossman 1973; Snelson and Pflieger 1975; Smith 1979; Lee et al. 1980; Trautman 1981).



FIGURE 1. Map of the revised Canadian distribution of the Redfin Shiner, *Notropis umbratilis*. Heavy lines represent lake watershed boundaries. Star = Middle Thames population reported herein. Circles = capture locations published previously. Squares = previously unreported capture locations. Symbols with embedded white squares are those on the Middle Thames River. Due to map scale, some symbols represent multiple capture sites in close proximity.

The Middle Thames site is approximately 20 km west of the nearest previously published population from the South Thames River near Woodstock, Ontario (Hubbs and Brown 1929). However, an examination of Ontario Ministry of Natural Resources (OMNR), Royal Ontario Museum, and National Museums of Canada records revealed that the species is more widespread; 126 verified but unreported Redfin Shiner collections includes two in the upper portion of the Middle Thames River (Figure 1).

In more southerly portions of their range, Redfin Shiners are known to spawn in aggregations over the nests of various centrarchids, including Longear Sunfish (Snelson and Pflieger 1975), Green Sunfish, *Lepomis cyanellus* (Hunter and Wisby 1961; Hunter and Hasler 1965; Snelson and Pflieger 1975), and Orangespotted Sunfish, *L. humilis* (Snelson and Pflieger 1975; Trautman 1981). Scott and Crossman (1973: 473) suggested that in Ontario "water temperature differences...may prevent such close ecological associations". They reported Redfin Shiners from Black Creek, Ontario, in reproductive condition on 15 August 1946, inferring that suitable stream

temperatures for their breeding were likely to be attained only after the cessation of sunfish spawning in spring. However, in Middle Thames River, water temperatures rise rapidly in spring: June water temperatures are typically in the 20–25°C range, and may exceed 30°C in July and August (Bietz 1980; Noltie 1982; Dupuis 1985). In our collections both Redfin Shiner and Longear Sunfish were taken in breeding condition on the same day in late June, the shiners from over occupied sunfish nests containing fertilized eggs. H. Dupuis (personal communication) has also observed aggregations of shiners with red fins over Longear Sunfish breeding colonies during studies of *L. megalotis* at this collection site (Dupuis 1985).

The distribution of Redfin Shiners may indicate an expanding Ontario range, possibly the result of the continued warming and siltation of Ontario's streams via reduction of riparian woodlands and increasing agricultural activity. Alternately the influx of hereto uncommon centrarchid species may provide host nests for spawning Redfin Shiners, e.g. Orangespotted Sunfish (Noltie and Beletz 1984) and Green Sunfish (OMNR Fish Species Distribution Data System and Lake Inventory Database surveys, 1983). The Redfin Shiner's presence here might instead be longstanding, but earlier overlooked. Recent range extension from downstream populations is unlikely to have given rise to populations such as the three now known from the Middle Thames River (Figure 1). In this case, the large Hunt, Springbank, and Thamesford dams further down the Thames River have stood since late in the last century and effectively block upstream access for even larger fishes (Ecologistics Limited. 1981. Final report. Feasibility study of removal or modification of the Thamesford and Hunt dams. Report to the Upper Thames River Conservation Authority. 85 pp.).

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helped search for or provided what original catch records were available from their OMNR districts. M. F. Goodchild and J. Lee of the University of Western Ontario's Department of Geography provided mapping expertise.

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First Nesting of the Glossy Ibis, *Plegadis falcinellus*, in Canada

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McAlpine, Donald F., Jaako Finne, Scott Makepeace, Scott Gilliland, and Mark Phinney. 1988. First nesting of the Glossy Ibis, *Plegadis falcinellus*, in Canada. *Canadian Field Naturalist* 102(3): 536–537.

A single Glossy Ibis, *Plegadis falcinellus*, was observed nesting on an island in the lower Bay of Fundy, New Brunswick, during 1986. This is the first recorded nesting for the species in Canada and represents a 400 km extension northward in the breeding range.

Key Words: Glossy Ibis, *Plegadis falcinellus*, breeding, Canada, New Brunswick.

Long a noted wanderer over much of the United States and eastern Canada, the Glossy Ibis, *Plegadis falcinellus*, has been steadily expanding its eastern North American breeding range northward, particularly since the 1940s and 1950s (American Ornithologists' Union 1957, 1983). Burger and Miller (1977) provided a good summary of the expansion of the species' breeding range in North America, and Godfrey (1986) summarized eastern Canadian observations of this bird from as early as 1828. Pough (1951) suggested that the Glossy Ibis may be a relatively recent North American arrival from the Old World, as authentic breeding records for this continent date back only to the 1880s. Currently the Glossy Ibis is known as a local breeder from southern Maine and Rhode Island south to Florida (American Ornithologists' Union 1983). Although *Plegadis falcinellus* was first recorded in New Brunswick as recently as 1952 (Squires 1976), early records from Prince Edward Island in 1878 and from Nova Scotia in 1865 (Godfrey 1986) suggest that this bird must have strayed on rare occasions throughout Atlantic Canada from at least the 1860s onward. Since first being recorded in New Brunswick, the Glossy Ibis has become a rare but regular visitant (Squires 1976). Here we document a substantial (400 km) northward extension in the breeding range of the Glossy Ibis, and in reporting a nest record of *Plegadis falcinellus* in New Brunswick, confirm this species as a breeding bird in Canada.

On 14 June 1986 we flushed a Glossy Ibis from a dense thicket of *Rubus* and Red Elderberry, *Sambucus pubens*, on Manawagonish Island (45° 12'N, 66° 06'W), New Brunswick. Manawagonish is an island of less than 20 ha about 1.5 km offshore in the lower Bay of Fundy. There are more than 2000 active Double-crested Cormorant,

Phalacrocorax auritus, nests on the island as well as numbers of nesting Herring, *Larus argentatus*, and Great Black-backed, *Larus marinus*, gulls and Great Blue Heron, *Ardea herodias*. The island has been visited regularly since 1940 for bird banding activities (Astle and McAlpine 1985). Upon searching the thicket we located a large, bulky nest of sticks and twigs containing three warm eggs. Upon later consultation with a field guide (Harrison 1978) the eggs were easily identified as those of Glossy Ibis, based on their deep blue coloration and elliptical shape, the first character readily separating them from those of any of the herons. The nest was located on the ground about 18 m into the thicket from the margin of an old field, in dense brush, and on the edge of a small opening in the 3 m high vegetation. The thicket was occupied by nesting Double-crested Cormorants, and a single Common Eider, *Somateria mollissima*, nest was located on the ground less than 1 m from the Ibis nest.

On 19 June McAlpine and Finne again visited the nest. There was no sign of any parent birds and only a single warmish egg of typical Glossy Ibis dimensions (54.2 mm × 36.2 mm) and weight (36.0 g) was in the nest.

Although there were no signs of eggshell fragments, it would appear that the nest was preyed on by gulls or Crows, *Corvus brachyrhynchos*, which were observed nearby. The single egg sank when placed in a container of water, indicating that it was only slightly incubated.

On 21 June when Finne next visited the nest no eggs remained and there was no sign of the parent birds. McAlpine also saw no sign of the parent birds on 23 June, when the nest was collected for addition to the bird collection at the New Brunswick Museum (NBM 6008). Upon close

examination the nest was found to contain a single Glossy Ibis breast feather.

This breeding record was not unexpected. Palmer (1962) noted that *P. falcinellus* has a reputation for island-hopping, and it has become well established as an island breeder in southern Maine since first nesting in that state in 1972 (Tyler 1977). At least seven birds spent the summer of 1985 feeding in a saltmarsh adjacent to Manawagonish Island and were noted travelling back and forth between the marsh and the island. A pile of sticks noted next to the nest may have represented a nesting attempt during the 1985 season. It does not appear that that nest was ever completed, as it lacked any sign of nest lining material. There have been frequent incursions of Glossy Ibis in New Brunswick since the early 1970s, with peaks in 1972 (28 birds observed) and 1985 (14 birds observed). The first immature bird in the province was noted at Castalia Marsh, Grand Manan, in August 1973 and a pair were observed displaying at a marsh in central New Brunswick in 1974. Palmer (1962) noted that the Glossy Ibis almost always nests in association with herons or other waders. The New Brunswick nest was situated close to six of the 10 Great Blue Heron nests active on Manawagonish Island in 1986.

Burger and Miller (1977) found the Glossy Ibis versatile in its selection of nesting habitat. They suggested part of the reason for the rapid increase in numbers of this bird may be the availability of dredge-spoil islands along the Atlantic Coast and the Ibises' apparent preference for such sites for nesting. Although Manawagonish Island is not a dredge-spoil island, the large numbers of nesting cormorants have killed most of the trees on the island and appear to be maintaining much of the island in an early successional stage, a feature favourable for the nesting of many coastal birds (Burger and Miller 1977). Further monitoring of

the presence and activities of the Glossy Ibis in the northeast should provide insight into the dynamics of range expansion in this species.

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Henri Ouellet, National Museum of Natural Sciences, confirmed that this was the first nesting of the Glossy Ibis in Canada. Tony Erskine, David Christie and Peter Pearce provided useful comments on the manuscript.

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Bowhead Whale, *Balaena mysticetus*, Sightings off the Coast of Manitoba

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Watts, Paul D. 1988. Bowhead Whale, *Balaena mysticetus*, sightings off the coast of Manitoba. *Canadian Field-Naturalist* 102(3): 538-539.

The Bowhead Whale (*Balaena mysticetus*) has not been reported in Hudson Bay, as far south as Churchill, for almost two hundred years. During the summer of 1984 I observed a bowhead in the Churchill River estuary. In addition, this paper reports three possible sightings during the two subsequent summers.

Key Words: *Balaena mysticetus*, Bowhead Whale, Churchill, Hudson Bay.

In the 18th century, Bowhead Whales (*Balaena mysticetus*) were occasionally observed close to Churchill. A total of three were captured close to Churchill during a twenty year period in the last half of that century (Hearne 1795: 392). The present observations are the only other sightings in south-western Hudson Bay that have been reported. Ross (1979) has estimated that 28 394 Bowhead Whales were harvested in Davis Strait between 1719 and 1911, with an additional 572 taken in Hudson Bay from 1860 to 1915. Estimates of the present eastern Canadian Arctic population range from 100 (Davis and Koski 1980) to several hundred (Mansfield 1985) individuals.

On 17 August 1984, during an aerial census of Beluga Whales (*Delphinapterus leucas*) a bowhead was sighted at the mouth of the Churchill River (58°48'N, 94°12'W). The whale was identified by the white lower jaw and the characteristic shape of the body (Banfield 1981). During the second week of August 1986, a marine mammal sighting, which fits the description of a bowhead whale, occurred at the same location (M. Bussell, personal communication). In the summer of 1985 two large dark whales that were most likely bowheads were sighted approximately 300 km north of Churchill close to Eskimo Point (R. Walker, personal communication).

The presence of the beluga survey team permitted observation of the 1984 specimen for a period of about one hour. The total body length of the Bowhead Whale was estimated to be between 7.5 and 9 m. Length estimations were based upon observations from the air and from the survey boat. Observers in the airplane were able to compare the size of the large whale with the accompanying beluga. An observer in the 6 m survey boat was able to estimate size relative to the boat. The length of the specimen would indicate an age of approximately one year (Nerini et al. 1984).

There were approximately 200 belugas in the area of the Churchill estuary when the 1984 sighting occurred. The Bowhead Whale was accompanied by six adult belugas. The bowhead and the beluga pod were in estuarine waters approximately 8 m deep. The observation was made at low tide where water temperature was between 10.5°C and 11°C to a depth of 3 m. These temperatures were representative of those found throughout the river plume.

Aerial observations were conducted from a Cessna 206 approximately 300 m above the surface. Richardson et al. (1985) found some evidence that similar observations from a Britton-Norman Islander twin-engined aircraft caused behavioural changes in the bowhead. In the present work the effect of aircraft noise was minimized by not flying directly over the whales and reducing power when the bowhead surfaced. The bowhead initiated a dive every five to ten minutes during the hour of observation. The belugas, which were sometimes within 1 m of the bowhead, dove in synchrony with the large whale each time it began its dive. Reports by local residents indicate that this bowhead, or a similar whale, remained close to the Churchill estuary for a minimum of one week.

In the southern Beaufort Sea, Bowhead Whales tend to feed along the edge of the Mackenzie River turbidity plume (Borstad 1985). The Churchill River may have a similar attraction for bowheads from the eastern Arctic population that enter southern Hudson Bay. The extralimital observations reported in the present work during August of two separate years are unusual since Ross (1974) concluded that at this time of year the population would be at the extreme north of its range.

Analysis of catch data and observations from whaling expeditions are inconclusive in determin-

ing whether the bowhead was a winter resident in Hudson Bay (Ross 1974). Present studies of the eastern Arctic bowhead are limited by very small numbers distributed over a vast area.

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Hedge Woundwort, *Stachys sylvatica* (Labiatae) in Canada

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Hedge Woundwort, *Stachys sylvatica* L., was discovered in 1986 growing in abundance in deciduous woodland by the Medway River within the city limits of London, Ontario. This is the first known record of this European species from Canada.

Key Words: *Stachys sylvatica*, Hedge Woundwort, Ontario, Canada.

The discovery of Hedge Woundwort, *Stachys sylvatica* L., growing in abundance in deciduous woodland within the city limits of London, Middlesex County, Ontario, adds another species to both the Ontario and Canadian floras. My attention was drawn to the occurrence of this plant by Mr. Larry Lamb who brought in a leafy shoot of an unknown member of the mint family (Labiatae) in the spring of 1986. I returned with Mr. Lamb to the site in early summer to establish the identity of the plant and we found it growing abundantly over several acres of woodland around the confluence of Snake Creek and the Medway River.

The Hedge Woundwort is a common woodland and hedgerow plant in Britain and western Europe,

and was no doubt introduced into the London area from that region. In the London site it is growing with several other notable aliens, also originating from Europe. These include Wood Sedge, *Carex sylvatica* Hudson, which is abundant over much of the woodland floor, and Sharp Dock, *Rumex conglomeratus* Murray, which occurs scattered through the woodland on the river flood plain.

Hedge Woundwort can readily be distinguished from other species of woundwort, *Stachys*, occurring in eastern and central Canada by its large triangular-ovate and cordate leaves, its long rather scattered transparent hairs, its strong unpleasant odour, and its dark dusky-pink flowers. Figure 1 shows the general features of this



FIGURE 1. Specimen of Hedge Woundwort, *Stachys sylvatica*, from R. Medway at the junction with Snake Creek, London, Middlesex County, Ontario.

plant and is taken from a specimen collected at the London location. Hedge Woundwort has been reported from the eastern United States as an adventive weed in New York and Pennsylvania (Fernald 1970), but in the recently published checklist of New York State plants, Mitchell (1986) states that this species is no longer known to exist in that state.

Voucher specimens: *Morton* NA16944 (JKM, WAT, DAO, MICH, UAC). Woodland by the R. Medway at the junction with Snake Creek, London, Middlesex Co. Ontario. 17 June 1986. (See Holmgren et al. (1981) for acronyms.)

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Brown Bear, *Ursus arctos*, with Six Young

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Wilk, Randall J., John W. Solberg, Vernon D. Berns, and Richard A. Sellers. 1988. Brown Bear, *Ursus arctos*, with six young. Canadian Field-Naturalist 102(3) 541-543.

A female Brown Bear (*Ursus arctos*) accompanied by six young was observed on the Alaska Peninsula in 1983 and 1984. The circumstances surrounding the independent observations suggest the group was the same one both years. It may have been the result of orphaned or abandoned cubs being adopted, or an extremely rare occurrence of a litter of sextuplets.

Key Words: Brown Bear, *Ursus arctos*, Alaska Peninsula, cub adoption, litter size.

Sizes of litters of Brown Bears (*Ursus arctos*) have been reported in numerous studies. In coastal Alaska, data on age composition of Brown Bears are obtained from aerial surveys or streamside counts conducted in remote and essentially undisturbed areas where bears congregate on salmon (*Onchorynchus* spp.) spawning streams during summer and early fall (Klein 1958; Erickson and Siniff 1963; Troyer and Hensel 1964; Hensel et al. 1969; Glenn et al. 1976). Although it has generally been assumed that "litters" or "family groups" classified during surveys are siblings born at the same time of the same female, it has been suggested that abandonment with adoption is the likely explanation for large litters reported (Mundy and Flook 1973: 12; Bunnell and Tait

1985: 318). However, Hensel et al. (1969: 363) reported seven litters with four young from Kodiak Island and Alaska Peninsula and found no evidence of adoption. Evidence of adoptions (Erickson and Miller 1963) include known differences in age (Craighead et al. 1969: 462), and size and coat color disparities (Erickson 1964). Cubs we observe together (accompanied by an adult — the presumed mother) with similar physical and behavioral attributes are tallied as "litters" during stream surveys. We report here an unusually large litter of Brown Bears seen from a small aircraft.

On 24 and 26 August 1983, and again on 27 August 1984, Berns (pilot) and Solberg observed a female Brown Bear accompanied by six young.

These observations occurred while they were conducting aerial surveys of bears on streams on the Alaska Peninsula National Wildlife Refuge, Alaska. The sightings occurred in the upper reaches of two adjacent streams on the southeast side of lower Ugashik Lake (57° 26'N, 156° 41'W); maximum linear distance between observations was 2 to 3 km. The young were classified as a litter of 1.5 year-olds in 1983 and "older cubs" (≥ 2.5 years old) in 1984, based on subjective judgement of their comparable size and coat color uniformity. Both observers were experienced in bear surveys, Berns having extensive experience on Kodiak Island and the Alaska Peninsula.

In all cases, the female and young were fishing in narrow, shallow areas about 6–8 km above the lake, and were relatively isolated from the generally greater bear concentrations downstream. When the survey aircraft passed over, the whole group responded, with the six smaller bears following the adult into riparian shrub cover nearby. The predilection for bears to use the same fishing sites from year to year (Erickson and Miller 1963; Glenn et al. 1976; V. G. Barnes, personal communication) and the physical similarities of the young suggest the bears were the same group both years and may have been sextuplets. As far as we know, observations of six young with a maternal female Brown Bear in an apparent enduring relationship have not been reported elsewhere in the literature.

During fishing activities, some family groups of bears are gregarious, and others apparently develop a level of territorial tolerance which enables litters to intermix occasionally, resulting in families exchanging cubs (Glenn et al. 1976; L. Aumiller, personal communication), and thereby increasing the probability of adoptions (Erickson and Miller 1963; Erickson 1964) from abandonment of young. We have firsthand evidence of recent adoptions of cubs on the Alaska Peninsula. On 3 August 1985, during a study of Brown Bears at streams on Becharof National Wildlife Refuge, Wilk observed a female with two yearling cubs and one cub of the year (age classes based on obvious size and pelage differences). On 3 August 1986, in the same study area, Wilk observed another female with the same complement and age composition of young. C. P. Dau (personal communication) observed an adoption that occurred on Izembek Refuge of the southern Alaska Peninsula in 1984. He reported that a 16-year-old female with two cubs of the year was captured and radio-collared in Right-hand Valley on 30 July. The next day, the family group was observed together during a tracking flight, and was subsequently observed on 6 August. On 10

September, a third young was seen with the three bears. The additional cub of the year was judged to be about 1/3 smaller than the other two.

Cub exchanges and litter mixing resulting in females temporarily with six young have been reported at McNeil River by Erickson and Miller (1963) [also see Murie 1981: 75] and Glenn et al. (1976). In the latter paper, it was not possible for the authors to determine the final status of the family groups that apparently changed litter complements on a daily basis for the duration of fishing activities over the summer. These accounts suggest that cub exchanges or abandonment with adoption are perhaps not as rare on the Alaska Peninsula as might be in other areas of the species range, or that circumstances are such that biologists on the peninsula have more opportunity to observe these occurrences.

Nevertheless, the occurrence of more than four young in a litter of Brown Bears is rare (Onoyama and Haga 1982). Bunnell and Tait (1985) tabulated sizes of 824 litters from six populations of Brown Bears of which only 20 groups had four young, and one had five (6 of the 21 were from captive bears). Only three known observations of females with five young have been recorded from Kodiak Island (V. G. Barnes, personal communication). Females with five young were observed only twice in a 15-year study (1963–1978) on the Alaska Peninsula (Modafferi 1984). Recent data from the Alaska Peninsula further support the rarity of females with more than four young (Table 1). Only five groups

TABLE 1. Frequency (%) of observed sizes of "litters" of Brown Bears from aerial surveys on the Alaska Peninsula.¹

Size of litter	Cubs		Total
	Of the year	Yearling or older	
1	20.7	29.5	25.2
2	51.1	47.4	49.2
3	27.2	21.8	24.5
4	0.9	0.9	0.9
5			
6		0.4	0.2

¹n = 1520 observations including replicate surveys. Locations: McNeil River 1979–1985; Izembek Refuge 1968, 1976–1983, 1985; Black Lake 1982–1986; Canoe Bay 1983; and Game Management Unit 9A 1982; Becharof Refuge 1980–1986; Alaska Peninsula Refuge 1981–1984, 1986; all U. S. Fish and Wildlife Service and Alaska Department of Fish and Game unpublished data; Becharof Lake 1974 (W. Troyer, 1975. Brown Bear studies-Katmai. National Park Service Report, Anchorage, Alaska. 17 pp.).

with four young, and none with more than four were tallied from over 1500 classified except for the groups of six reported here.

Although the "litter" of six young could have been the result of an abandoned or orphaned litter being adopted by a female and her cubs, the relationship among these bears was apparently a lasting one (i.e., at least August 1983 – August 1984) and the observations provided no evidence of intermingling of young from different family groups nor of adoption. We cannot conclude empirically that the young were siblings, but a high nutritional plane, contributing to higher reproductive rates and larger litters (Craighead et al. 1976; Bunnell and Tait 1981; Modafferi 1984; Knight and Eberhardt 1985) such as the high protein diet of salmon enjoyed by bears on the Alaska Peninsula, may increase the likelihood of an occasional large litter of Brown Bears occurring in the area.

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Colonization of Snow Bunting, *Plectrophenax nivalis*, Nests by Bumblebees, *Bombus polaris*, in the High Arctic

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Two instances of colonization, believed to be instances of usurpation, of Snow Bunting nests by Arctic Bumblebees were observed in the High Arctic on Devon Island, Northwest Territories.

Key Words: Arctic Bumblebee, *Bombus polaris*, Snow Bunting, *Plectrophenax nivalis*, colonization, Arctic.

The Arctic Bumblebee, *Bombus polaris*, normally establishes its colonies in abandoned lemming nests on or in the ground (Milliron and Oliver 1966; Richards 1973). We report here two instances where *B. polaris* colonized Snow Bunting, *Plectrophenax nivalis*, nests and may have displaced actively nesting female buntings.

In early July 1982 we found about 15 *B. polaris* workers in a Snow Bunting nest with three eggs. The nest was in a south-facing rock cleft approximately 2 m above the ground on Truelove Lowland, Devon Island, Northwest Territories (75° 33' N; 84° 40' W). The bees had enmeshed the eggs in a comb, and had covered their larval brood with the nest's feather lining.

On 29 June 1986, we found another Snow Bunting nest containing two fresh eggs in the same nest site (the previous nest had been removed). The nest lining of fine grasses and feathers was fluffed up and a compartment in the nest cup contained a honey-pot attached to one of the bird's eggs and a brood clump with 20 bee larvae, indicating that the bumblebee nest was in its initial stage of development (Richards 1973). The brood was being incubated by the queen bee and no female Snow Bunting was in attendance.

Nest-seeking queen bumblebees select well-insulated and insulated nest sites protected from predators. The Snow Bunting nests at the rock outcropping fit these criteria. Such sites may be difficult to find within the brief period when queens establish nests at the onset of Arctic summer in June.

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A Second Record of the Mosquito Fern, *Azolla caroliniana*, in Ontario

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Cody, William J., and Frederick W. Schueler. 1988. A second record of the Mosquito Fern, *Azolla caroliniana*, in Ontario. *Canadian Field-Naturalist* 102(3): 545-546.

The first 20th century record of Mosquito Fern, *Azolla caroliniana*, from Canada is reported, and its decline in New York State is discussed.

Key Words: Mosquito Fern, *Azolla caroliniana*, Ontario, New York, aquatic plants.

Members of the genus *Azolla* (Salvinaceae) are small, annual, aquatic, free-floating plants with unbranched thread-like roots. The plants are compact, dichotomously branched and form small mats. The leaves are usually crowded and two-lobed, the upper lobe green or often reddish later in the season, the lower lobe usually larger than the upper, mostly without chlorophyll and only one cell thick (Cody and Britton, *in press*). Only two species are known in Canada, *A. mexicana* in the Shuswap Lake region of southern British Columbia (Brunton 1986) and *A. caroliniana* in southern Ontario.

These two species may be distinguished by size, *A. caroliniana* being usually less than 1 cm in diameter while *A. mexicana* is 1 cm in diameter or larger, and under high magnification, the glochidia (peculiar barb-tipped hairs on the microspores) of *A. mexicana* have cross walls whereas those of *A. caroliniana* do not.

Pursh (1814) reported *A. caroliniana* from Lake Ontario but gave no indication of the exact locality in which it was found, or even whether it was from Canada or the United States. For New York State, Paine (1865) reported that *A. caroliniana* was "In all the side-waters of Lake Ontario, from the marshes five miles northeast of Oswego, to Braddock's bay, Monroe county: often completely covering the water with a purple velvet mantle." Wiegand and Eames (1925) stated for this species "Quiet waters; very rare; Cayuga Marshes, at the foot of Cayuga Lake, 1879; not seen in recent years."

The only known locality for *A. caroliniana* in Ontario was at Burlington Beach near Hamilton. Macoun (1890) reported collections by Logie and Buchan from that locality. A specimen collected by Judge Logie in 1862 was in the Lawson Herbarium and is now in the Herbarium of the National Museum of Natural Sciences at Ottawa (Cody and

Britton, *in press*). Soper (1949) reported, "Apparently this plant has not been observed recently in Ontario and is probably now extinct" but noted that *A. caroliniana* was reported from two localities on the American side of the Niagara Frontier region (Niagara Co., New York, Zenkert 1934). Boivin (1968) inadvertently omitted the whole genus in his list of Canadian taxa, despite these records and several for the western *A. mexicana*. Argus and White (1977) state that it is "rare and possibly extirpated in Canada."

Lellinger (1985) considered *A. caroliniana* to be a rare plant in the United States. He gave the range as "Massachusetts and New York on the coastal plain to Florida west to Louisiana. Also in Mississippi, Tennessee, Kentucky and perhaps Illinois, along the east side of the Mississippi River valley." Small (1935) stated that "It is sometimes called mosquito-fern because it is grown to check the natural breeding of mosquitoes in pools where these pests generally breed . . . Although our area [New York] may be within the natural range of this species it seems to occur there only as naturalized colonies. . . ." The species is also cultivated in aquaria and decorative pools (Lellinger 1985).

Cranfill (1980) observed that although *A. caroliniana* may be abundant in any given place during the growing season, that it is generally ephemeral, and because of this, he suggested that it might continually be reintroduced by migrating waterfowl. The plant reproduces very quickly vegetatively. The fact that megaspores of *A. caroliniana* were unknown in the United States to Svenson (1944) and Lellinger (1985) lends support to the idea of avian transport. However, Perkins et al. (1985) do record a megaspore-bearing *A. caroliniana* from Port Clinton, Ohio.

The recent publication on the status of another species of Mosquito Fern, (*Azolla mexicana*) in

Canada (Brunton 1986) recalled the finding of *A. caroliniana* in the Thousand Islands region of Leeds County in 1981 to F.W.S.. Data for this collection are as follows: ONTARIO, Leeds Co., mouth of Knights Creek, 10 km E and 2.5 km N of Gananoque (2 km WSW of Ivy Lea, 44°22' N 76°10' W, *F.W. Schueler* s.n., 21 August 1981 (DAO, CAN, OAC, TRT). (Acronyms follow Holmgren et al. (1981)).

At the time of collection, the entire bay at the mouth of Knights Creek at the St. Lawrence River, south of the Thousand Islands Parkway, was red with *Azolla* except around the shores where the plants were greener in the shade of cattails (*Typha* sp.). This species was not observed by W.J.C. during his survey of St. Lawrence Islands National Park and vicinity in 1975, nor has it been found there since (Keith Dewar, February 1987, personal communication).

Robert Dirig of the L.H. Bailey Hortorium, Cornell University, and Charles J. Sheviak of the New York State Museum Biological Survey have provided us with lists of collections of this species from New York State. New York records of *A. caroliniana* accumulated at the rate of about 1 record/5 years from 1860 until 1938. Then in 1939 R. T. Clausen found *A. caroliniana* in seven sites along Lake Ontario in Wayne and Monroe counties (BH). There are only two records from New York State since then: several collections from Cross Lake, Onondaga and Cayuga counties, September and October 1945, and Mud Creek near Euclid, Onondaga Co., 5 October 1951, *K. L. Brooks, et al.* (NYS).

This collection record suggests that there has been a decline in northern occurrences of the species since 1940, since there has been considerable interest in aquatic flora at the New York State Museum, especially during the 1950s, and this pattern of a declining number of records is not seen in the bulk of the flora (Sheviak, *in litt.* 21 April 1987). If these little ferns were carried north by migrating waterfowl, their occurrence in the north may be dependent on the numbers and migratory patterns of ducks and geese. These birds are less abundant and wintering farther north in recent decades, so they may have less opportunity to pick up *Azolla* in the southeastern United States.

We cannot speculate whether the population reported here was initiated by avian or human transport, although its temporal and spatial isolation, and proximity to major highway, navigation, and tourist routes might argue for the latter. Because it was not realized at the time how

unusual the record was, no wider search was made for other populations that might have been in the Thousand Islands area in 1981. D. Brunton (personal communication, February 1987) did not find *Azolla* in nearby marshes at Point Comfort on 4 June and 30 July 1981.

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A Range Extension for the Crayfish *Orconectes rusticus*: Sibley Provincial Park, Northwestern Ontario.

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Momot, Walter T., Connie Hartviksen, and George Morgan. 1988. A range extension for the crayfish *Orconectes rusticus*: Sibley Provincial Park, northwestern Ontario. *Canadian Field-Naturalist* 102(3): 547–548.

A new Ontario locality record is described for the crayfish *Orconectes rusticus* (Girard) from Pounsford Lake, Sibley Provincial Park, northwestern Ontario (48°29'N, 88°46'W). A total of 108 *O. rusticus* were collected in September 1985. This represents an extension of at least 300 km from any of its previously reported western locations and several hundred from any southern or eastern locations.

Key Words: Crayfish, *Orconectes rusticus*, range extension, Ontario, Sibley Provincial Park.

The crayfish *Orconectes rusticus* is an introduced species (Crocker and Barr 1968) which has been slowly expanding its range in Ontario at the expense of native species. It has now reached the Kawartha Lakes region and is one of the two most common species of *Orconectes* found in southern Ontario (Berrill 1978; Berrill and Arsenault 1982). Our discovery now places the species immediately north of Lake Superior, a range extension of several hundred kilometers.

Pounsford Lake (48°29'N, 88°46'W) is a small lake (127 ha.) located in the north end of the Sibley Peninsula, which separates Thunder Bay from Black Bay in Lake Superior. The lake has a mean depth of 7 m and an alkalinity of 61.6 mg/l CaCO₃. This clear water lake drains via a small intermittent stream into the Portage River System which in turn drains into Black Bay, Lake Superior. The shores of Pounsford Lake are wooded and the bottom is mainly rubble gravel and sand with submerged vegetation in the shallow bays.

A single specimen of *Orconectes rusticus* was discovered on 27 September 1985 while seining fish. On 30 September, six modified minnow traps, baited with fish, were set at 0900 hrs and lifted on 1 October at 1400 hrs. The traps caught a total of 132 crayfish in this lake: 108 *O. rusticus* and 24 native *O. virilis*. This lake is part of Sibley Provincial Park which receives considerable recreational use. The male *Orconectes rusticus* had mean cephalothorax length (C.L.) of 33.4 mm (S.D. = 4.5 mm, n = 86). Females had a mean C.L. of 31.8 mm (S.D. = 3.7, n = 18). Male *O. virilis* had a mean C.L. of 34.3 mm (S.D. = 3.4 mm, n = 23). Only one female was captured with a mean C.L. of 40 mm. All distributions were normally distributed. *Orconectes rusticus* ranged in size from 25 to

50 mm (C.L.) for males and 23–37 mm (C.L.) for females; while male *O. virilis* were 28–41 mm (C.L.).

The advance of *O. rusticus* into eastern Ontario to the southern edge of the Precambrian Shield is well documented by Berrill (1978). This crayfish is broadly distributed over the north central United States and southern Ontario. The species, native to the lower midwestern United States, has extended its range to northern Wisconsin (Capelli and Magnuson 1983) and central Minnesota (Phillips and Reis 1979), and is recorded from Lake-of-the-Woods in the extreme western portion of Ontario (Crocker and Barr 1968).

In our area, this crayfish appears confined to Pounsford Lake. Its presence has not yet been noted in either the Portage River, Black Bay, or other Sibley Provincial Park lakes. Its presence on the north coast of Lake Superior therefore represents a range extension of several hundred kilometers from any of its previously reported locations. It is almost certain that the population in Pounsford Lake is introduced. A likely source of the introduction may have been the Ontario Ministry of Natural Resources which accidentally stocked Largemouth Bass, *Micropterus salmoides*, into Pounsford Lake in the early 1950s. These fish came from a hatchery in southeastern Ontario. Quite possibly *Orconectes rusticus* were introduced at that time. Should it access the relatively warm waters of Black Bay it could become established in Lake Superior. Whether *O. rusticus* replaces *O. virilis* in Lake Superior may depend on the ability of this species to acquire sufficient energy reserves to permit growth and complete its life cycle in this cold oligotrophic lake. At 19–20°C the hourly oxygen consumption rate of *O. rusticus* is considerably above that of *O. virilis* (Momot 1984). A species with a higher

metabolic rate may incorporate less energy per unit time in a habitat with low temperatures and low nutrients. In most of Lake Superior the bioenergetic advantage may be with *O. virilis*.

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New Station for *Malaxis paludosa*, Bog Adder's-mouth Orchid, in Northwestern Ontario

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Zoladeski, Christopher A. 1988. New station for *Malaxis paludosa*, Bog Adder's-mouth Orchid, in northwestern Ontario. *Canadian Field-Naturalist* 102(3): 548–549.

A new station for *Malaxis paludosa* (Bog Adder's-mouth Orchid) in Ontario is reported based on a collection from the area west of Lake Nipigon.

Key Words: *Malaxis paludosa*, Bog Adder's-mouth Orchid, boreal forest, Ontario.

Malaxis paludosa (L.) Sw., Bog Adder's-mouth Orchid, is one of the rarest orchids in North America. Circumboreal in distribution (Hultén 1958; Luer 1975), it is infrequent even in its principal area of north-central Eurasia. First records of this tiny orchid in North America date back to the turn of the century. Depending on the source, the species was not found until 1895 (Whiting and Catling 1986) or 1905 (Luer 1975; Baldwin 1961), when it was discovered in northern Minnesota. Shortly thereafter, in 1909, Henry C. Cowles found it on the Sibley Peninsula, northeast of Thunder Bay (Morris and Eames 1929; Baldwin 1961). The species appears to persist at this site, for the station was confirmed in 1967 (Whiting 1968).

Apart from the Sibley station, Bog Adder's-mouth Orchid has been collected only from a few widely scattered localities in northern Ontario. Argus and White (1982) indicate only two other stations, while Whiting and Catling (1986) describe three additional localities: near Wabimeig Lake

(NW Cochrane District), Kennedy Township (SE Cochrane District), and Harley Township (Timiskaming District).

The existence of a fifth station in Ontario is reported here (Figure 1), west of Lake Nipigon (Thunder Bay District), along highway 527 from Thunder Bay to Armstrong. This locality is approximately 4 km north of the bridge on the Kabitotikwia River (49°37'N, 89°12'W). The collection was made on 11 August 1986 during my field work on the composition of the boreal forest of northwestern Ontario. Two flowering and two immature plants, growing centimetres apart were collected. No further investigation, as to the areal extent, size and vigour of other colonies was undertaken at the time of collection. However, considering the homogeneity of the habitat and its extent, additional individuals of this species are likely present at the site. The specimens are deposited in the Erindale College Herbarium (TRTE, Number 42591), Mississauga, Ontario (Holmgren et al. 1981).

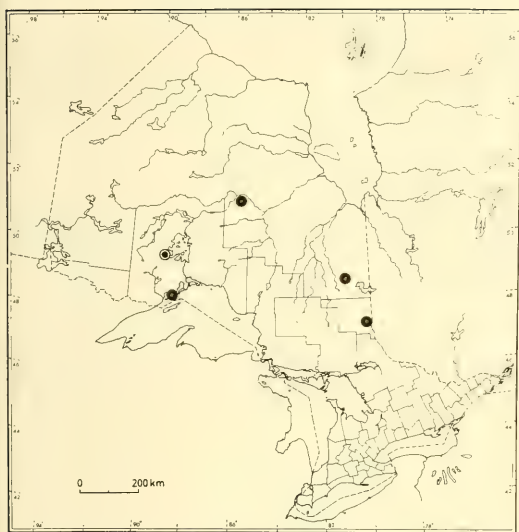


FIGURE 1. Distribution of Bog Adder's-mouth Orchid, *Malaxis paludosa* (L.) Sw., in Ontario. ● after Whiting and Catling (1986); ○ new station.

The plants were found on peat moss (*Sphagnum fuscum*, *S. magellanicum*) mounds in a mature lowland mixed *Picea mariana* (Black Spruce)-*Abies balsamea* (Balsam Fir) forest. Both canopy and reproduction layers, consisting of fir, spruce and occasionally Eastern White Cedar (*Thuja occidentalis*), were somewhat discontinuous because of windfalls of shallowly rooted trees which created multiple gaps in the strata. This also caused a very hummocky microrelief with small pools of stagnant water and mounds composed of peat moss. A thick shrub layer of *Alnus rugosa* (Speckled Alder) was present, with *Ledum groenlandicum* (Labrador Tea) and *Chamaedaphne calyculata* (Leatherleaf) growing underneath. The herb layer was very rich floristically, with *Calamagrostis canadensis* (Bluejoint), *Rubus pubescens* (Dwarf Raspberry), *Cornus canadensis* (Bunchberry), *Gaultheria hispida* (Creeping Snowberry), *Coptis groenlandica* (Goldthread), *Smilacina trifolia* (Three-leaved Solomon's Seal), *Linnaea borealis* (Twinflower), *Vaccinium oxycoccos* (Small Cranberry), and sedges (*Carex disperma*, *C. pauperula*, *C. brunnescens*).

The forest was located in a very large (10 + ha), poorly drained depression filled with peat in varying degrees of decomposition and depth. In terms of the Canadian Classification (Canada Soil Survey Committee 1978), the soil was a mesic fibrisol composed of two organic horizons: Of (15–25 cm) consisting primarily of living peat moss, and Om

(15 + cm) displaying an intermediate stage of decomposition. The upper soil horizon was strongly acidic (pH 5.3).

The habitat seems typical of the Adder's-mouth Orchid. Both Baldwin (1961) and Whiting (1968) found the species growing in wet open Black Spruce bogs between *Sphagnum* and other mosses. Whiting and Catling (1986) describe its usual habitat as "wet peaty or turfy bogs or fens, either open or partially shaded by alders and conifers". Also, it appears that this particular site may be additionally influenced by recent construction on the highway, probably causing a slight rise of ground water level, which presently varies from 0–25 cm below the soil surface.

Many researchers and naturalists (Baldwin 1961; Luer 1975; Petrie 1981) suggest that this orchid may be easily overlooked. It would not be surprising if it is present in areas between the currently disjunct stations in Ontario and those in British Columbia. However, easy access to much of this potential range is limited and extensive investigations may be difficult.

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Suppression of Reproduction in Upper Michigan White-tailed Deer, *Odocoileus virginianus*, by Climatic Stress During the Rut

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Verme, Louis J., and Robert V. Doepker. 1988. Suppression of reproduction in Upper Michigan White-tailed Deer, *Odocoileus virginianus*, by climatic stress during the rut. *Canadian Field-Naturalist* 102(3): 550-552.

Acute physiological stress following an unseasonably early blizzard apparently inhibited folliculogenesis (hence estrus) among adult White-tailed Deer (*Odocoileus virginianus*) in Upper Michigan during the 1985 rut. A fourfold increase in the proportion of non-pregnant does occurred that breeding season compared to the long-term mean, 4.7 versus 17.5%, respectively. There was no evidence that inadequate nutrition during pre-rut prompted this outcome, nor that prenatal mortality was a factor.

Key Words: White-tailed Deer, *Odocoileus virginianus*, climatic stress, breeding season, folliculogenesis, Upper Michigan.

Since 1950, Michigan wildlife biologists have determined the annual fecundity of adult (≥ 1.5 years old) female White-tailed deer (*Odocoileus virginianus*) by necropsying accidentally-killed specimens (mainly highway fatalities) from March through May, i.e., during the last trimester of fetal development. The 1986 study revealed that 17.5% of the does sampled ($N = 63$) in Upper Michigan (45° – $47^{\circ}30'N$) were not pregnant (Table 1), a fourfold increase over the long-term (32 years) mean of 4.7% (Friedrich and Hill 1982). Because nutritional plane prior to the breeding season greatly influences a doe's reproductive performance (Verme 1965, 1969; Ozoga and Verme 1982), an unexpectedly poor diet could account for the inordinately high proportion of barren does in the 1985 rut. But there was no evidence that forage supplies that season were appreciably lower than in previous years (Verme and Ozoga 1981). Autumn weather in our region typically is ameliorated by the maritime influence of Lake Michigan and Lake Superior, which helps maintain does in good physical condition during this critical period in their reproductive cycle.

On 1 December 1985, however, an unseasonably early blizzard raged across Upper Michigan, with winds gusting to 40 km/hr. This 2-day storm produced extreme wind chill and thickened the snow cover to > 50 cm over most of the region. The weather severity index (Verme 1968) for that week averaged 6.50, one of the highest readings of the entire 20-week winter (Michigan Department of Natural Resources, unpublished data). We therefore hypothesize that the rigorous living conditions accompanying this blizzard exacer-

bated the normal physiological decline in deer vigor to the point where many more does than usual did not achieve estrus.

Even under optimum nutrition, 5–10% of Upper Michigan adult does do not breed until December (Verme et al. 1987). Nutritional constraints may delay or completely suppress ovarian activity, and thus onset of estrus (Verme 1965, 1969). Age criteria for fetuses (Short 1970) examined indicated that few if any litters were conceived in December. Based on the large proportion of physically mature bucks in the annual kill, it is extremely unlikely that lack of sires was responsible for the breeding failure of so many does during the 1985 rut.

There was no evidence that fetal atrophy was responsible for the unusually large number of barren does. (A possible instance of abortion, involving an aged doe ≥ 12 years old, was excused because it could not be verified unequivocally.) Prenatal mortality probably was negligible (as normally found), since the rate of 1.75 fetuses/pregnant doe was identical to the long-term mean (Table 1); i.e., does that had bred in the 1985 rut were as prolific as ever. Gross fecundity, on the other hand, dropped to an all-time low because of the high incidence of non-productive does in the sample.

Study of tagged animals has shown that many Upper Michigan deer travel long distances (> 60 km) in moving from summer range to winter yards (Verme 1973). Generally, deer do not retreat to their traditional yarding areas until forced to by inclement weather, such as a blizzard (Verme 1973; Nelson and Mech 1981). The sudden, bitter storm

TABLE 1. Reproductive characteristics of Upper Michigan White-tailed Deer in the 1985 rut versus the long-term means.

Year	Adult does sampled	% not pregnant	Fetuses/ doe	Fetuses/ pregnant doe
1950-1981	3151	4.7*	1.65	1.73
1985	63	17.5*	1.44	1.75

*Values differ significantly ($P < 0.05$).

on 1 December 1985 undoubtedly resulted in some deer making an enervating trek through thick snow cover to reach sheltered sites. Moreover, most deeryards in this region currently provide scant food, and logging has fragmented these conifer swamps, thereby seriously reducing their cover value. Especially in areas of high herd density, deer were crowded together in sites still providing some vital respite (i.e., thermal comfort) from harsh weather (Verme 1968; Verme and Ozoga 1971).

Nutritional deprivation ultimately became intense, and a catastrophic die-off of tightly yarded deer was averted only by a fortuitous rapid snowmelt in late March 1986. Nevertheless, an estimated 77 000 animals died overwinter in the $> 40\,000\text{ km}^2$ region. A dead deer survey in an area supporting the largest population (averaging 20 deer/ km^2 ; Hill and Pohl 1983) revealed a loss of 5.6 animals/ km^2 (Hill 1986). Approximately 82% of the dead deer that could be aged were fawns.

Although published literature pertaining to the situation documented here apparently do not exist, we discovered a report from Saskatchewan concerning a remarkably similar cause-and-effect relationship (vis: An analysis of the deer feeding program during the severe 1984-85 winter in Saskatchewan. Saskatchewan Parks and Renewable Resources Wildlife Branch Report. 1985). Ordinarily, White-tailed Deer in that province are extremely productive, averaging 2.10 fetuses/doe; only 1 (2%) of 50 specimens examined in an earlier study was not pregnant (Stewart and Runge 1985). In contrast, necropsy of adult does (mainly car-kills) whose reproductive status could be determined with certainty showed a gross fecundity of only 1.42 fetuses/doe for the 1984 rut. This low rate stemmed from the fact that 16.4% of the specimens examined ($N = 55$) were barren. Nearly equal numbers of yearlings and older does were non-pregnant following that rut; as also was the case in Upper Michigan. Only a single instance

of fetal resorption was observed in the 1984-85 reproductive study in that province.

Autumn weather in southeastern/southcentral Saskatchewan in 1984 was characterized by abnormally low temperature and exceptionally heavy snowfall. Some localities had received 46-80 cm of snow by the end of November. Strong winds and a thick, crusted snow cover prevented deer from feeding on waste grain (their normal fare) in farm fields. Despite a massive supplemental feeding program, considerable starvation mortality occurred during the 1984-85 winter.

It is difficult to believe that the strikingly parallel situations noted for Michigan and Saskatchewan arose purely by chance. To the contrary, we contend that in both instances highly stressful conditions relatively late in the rut inhibited folliculogenesis in as yet unbred does, resulting in an unusually high proportion (16-17%) of barren does for the respective breeding seasons. One would surmise that this reproductive response occurs more frequently than previously suspected where inclement autumn weather occasionally prevails in the northern fringe of the white-tail's range.

Acknowledgments

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Late Breeding in the White-tailed Deer, *Odocoileus virginianus*, in Northern Minnesota

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Kerr, Kenneth D., and William J. Peterson. 1988. Late breeding in the White-tailed Deer, *Odocoileus virginianus*, in northern Minnesota. Canadian Field-Naturalist 102(3): 552–553.

Two incidences of March–April breeding in White-tailed Deer, *Odocoileus virginianus*, one in the wild and one in captivity, are documented.

Key Words: White-tailed Deer, *Odocoileus virginianus*, breeding, Minnesota.

Northern White-tailed Deer (*Odocoileus virginianus*), normally breed in November (Verme et al. 1987), but Erickson (1952) documented one case in northern Minnesota where a doe apparently bred 10–29 March. Here we report on two occurrences of late-born White-tailed Deer fawns in northern Minnesota; one in the wild, the other in captivity.

The naturally occurring case involved a 1.5-year old doe (aged by tooth replacement: Severinghaus 1949) that died during parturition in Cook County, Minnesota (47°45'N, 90°23'W) on 2 October 1985. It had bred as a fawn sometime during 3–20 March 1985, based on a 196 to 213-day gestation period (Haugen and Davenport 1950; Verme 1965, 1969).

Pregnancy in fawns is an uncommon occurrence in the Cook County area; only 15 of 295 (5%) female fawns examined for reproductive activity over the past 15 years were pregnant (W. J. Peterson, unpublished data). The 53-kg deer had died in the driveway of a private residence and was examined within a few hours. The head and neck of a 3.6-kg female fetus was protruding from the doe's vulva. The fetus' right shoulder was dislocated causing it to become stuck in the birth canal which led to the death of both the doe and fetus.

Cheatum and Morton (1942, 1946) demonstrated that when female fawns do reach puberty and mate during their first year, this occurs a month later than

with adult females. Supplemental feeding of deer during the winter by residents in Cook County is very common, and this may have allowed this fawn to achieve puberty in March (Verme and Ozoga 1987).

The second recorded late breeding occurred in a Minnesota Department of Natural Resources captive deer herd at Grand Rapids Minnesota (47°15'N, 93°31'W), and was likely artificially induced. These deer were confined separately in small (6 × 15 m) pens from 19 December 1984–19 March 1986. In the spring of 1985, all surviving newborn fawns were taken from their mothers when 3-days old and hand reared in separate pens. On 19 March 1986, all the surviving animals (4 females < 1 yr, 8 females > 4 yr, 1 male < 1 yr, and 5 males > 3 yr) were released into a 0.8-ha enclosure. On 5 November 1986, a fawn was discovered which, by its size and behavior, appeared to be approximately two weeks old. The fawn accompanied an adult (> 4 yr) doe as identified by ear tag placement. Assuming that the fawn was at least two weeks old, and given the 196–213 day gestation period, the fawn's mother must have bred between 19 March and 9 April 1986. This would probably have been the fifth or sixth consecutive estrous cycle for that animal. The ability of northern White-tailed Deer females to repeat estrous cycles at least into March has been documented by Plotka et al. (1977). The fawn appeared to thrive until its death on 23 December 1986. A necropsy revealed a 17-kg female fawn suffering from acute white muscle disease. The carcass of another newborn female fawn was found in the enclosure during the spring thaw, March 1987. It is unknown whether this second fawn represents a stillborn sibling of the late-born fawn, or the progeny of another late-bred doe, but the first seems more likely.

Acknowledgments

We thank T. K. Fuller, and M. S. Lenarz for helpful suggestions in the preparation of this note.

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News and Comment

Errata: *The Canadian Field-Naturalist* 101(4)

Brunton, Daniel F. 1987. List of Original Descriptions Published in *The Canadian Field-Naturalist*: 1932–1986. *Canadian Field-Naturalist* 101(4): 627–635.

Five original descriptions were omitted from the list. They are as follows:

Asio otus subsp. *tuftsi* Godfrey, subsp. nov.

61(6) 1947 p. 196.

[insert on page 628, left column, as first entry below (1) Birds]

Sorex cinereus subsp. *ugyunak*, Anderson & Rand, subsp. nov.

59(2) 1945 p. 62.

[insert on page 628, right column, following *Phenacomys*]

Sorex obscurus subsp. *soperi*, Anderson & Rand, subsp. nov.

59(2) 1945 p. 47.

Synaptomys borealis subsp. *smithi*, Anderson & Rand, subsp. nov.

57(6) 1943 p. 101.

[insert together on page 628, right column, following *Sorex palustris*]

Gerardia maritima Raf. forma *alba* D. S. Erskine ex Klawe, forma nov.

69(3) 1955 p. 129.

[insert on page 630, left column, following *Eupatorium maculatum*]

Several totals in Figures 1 and 2 are changed by these additions. The most important are revisions of the total for original descriptions in the 1932–1986 period to 323 and the overall total for the journal to 738.

My thanks to W. E. Godfrey and D. S. Erskine for bringing two of these omissions to my attention.

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Alfred Bog

Conservationists have been successful in arranging for the purchase of a large tract of Alfred Bog, one of the most important wetlands in Eastern Ontario (for further details see *The Canadian Field-Naturalist* 102(2): 269). Your contribution towards this urgent environmental project of The Ottawa Field-Naturalists' Club is needed now. Please send cheque or money order to:

The Ottawa Field Naturalists' Club
Alfred Bog Fund
Box 3264 Postal Station 'C'
Ottawa, Ontario
K1Y 4J5

The Ottawa Field-Naturalists' Club is a "Charitable" Organization. Income tax receipts will be provided.

Restoring the Great Lakes — Means and Ends

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Gilbertson, Michael. 1988. Restoring the Great Lakes — Means and ends. *Canadian Field-Naturalist* 102(3): 555–557.

There is an ever-growing body of evidence that several of the Great Lakes have passed through a prolonged period of substantial releases of persistent toxic chemicals that have caused international transboundary pollution (IJC 1987). The situation was sufficiently serious that Canada and the United States made this the focal point of the 1978 Great Lakes Water Quality Agreement which has recently been renewed by the two countries. One of the baffling aspects of these releases is that the effects they have caused have been difficult to observe and even more difficult to attribute to a particular chemical or a particular source. An enormous amount of research and monitoring has been carried out by both the Canadian and United States governments as well as by Ontario and the eight Great Lakes states. Research on dated sediment cores shows (Durham and Oliver 1983) that since the end of the Second World War there have been gradual increases in the concentrations of persistent toxic chemicals until about 1970, after which time the levels declined. Long-term monitoring of Herring Gull, *Larus argentatus*, eggs, collected annually since the early 1970s from each of the Great Lakes, confirms that levels sharply declined in the mid-1970s until about 1980, but there has been little further improvement (IJC 1987).

During this period the reproductive success of the Herring Gulls improved from about 0.1 fledged young per nest to about 1 or more fledged young per nest (reviewed in Gilbertson, 1988). The high incidence of abnormalities (Gilbertson et al. 1976), including crossed beaks, duplicated feet and small eyes in various species of colonial fish-eating birds is seldom now seen except in highly contaminated locations such as Green Bay, Wisconsin, (Tim Kubiak, personal communication) and Saginaw Bay, Michigan (Dr. James Ludwig, personal communication). The situation seems to have improved.

The question now arises, “Has the situation improved enough, or should there be some greater

level of clean-up?”. This is an important question, because further clean-up carries multibillion dollar implications, and engineers and administrators not only in Canada but more particularly in the United States, where most of these chemicals originate (N.R.T.C., 1984), need pragmatic and tangible goals to work towards. The present goals contained in the 1978 and 1987 Great Lakes Water Quality Agreements are expressed as numerical water quality objectives, which are concentrations of persistent toxic substances in water or in organisms that should not be exceeded.

In preparing plans for clean-up there has been considerable confusion over means and ends. Compliance with water quality objectives is the chosen means that, it is assumed, will result in restoration of the Great Lakes. At present, however, there is no coherent statement of the degree of restoration that is the desired end. These water quality objectives have, however, been interpreted into discharge rates or loadings of persistent toxic substances that can be released under permit. This interpretation was not the intent of the drafters of the 1978 Great Lakes Water Quality Agreement, since they wrote that releases of persistent toxic substances should be subject to the principle of “zero discharge” and should be “virtually eliminated”. “Zero discharge” and “virtual elimination” have now come to be interpreted to mean “no injury”. The crux of the matter at this point is that if there is to be further clean-up there must be evidence of continuing harm from present releases. Harm by persistent toxic chemicals necessarily implies either economic damage or toxicological injury. Thus, the prevention of exposures to persistent substances that cause economic or toxicological injury should be one of the ends that is desired.

No good case has yet been made for economic damage though there have been restrictions on marketing and “health advisories” on consumption of fishery products contaminated with persistent toxic substances. Is there any continuing

toxicological injury? The evidence for effects on humans is sparse despite the existence of several sub-populations chronically exposed to high levels of Great Lakes chemicals. Where investigations have been undertaken they have shown effects on human reproduction including low birth weight, small head circumference and poor psycho-motor development in highly exposed infants (Fein et al. 1984). The scarcity of epidemiological studies means that the evidence for continuing toxicological injury is unlikely to come from the human health field. Biological investigations on reproductive success of the extensively studied Great Lakes Herring Gulls showed that there was a serious toxicological situation in Lakes Ontario and Michigan during the early 1970s but that throughout the Great Lakes basin the situation is essentially back to normal.

The problem with trying to demonstrate injury using the Herring Gull may be with the selection of this species (Gilbertson, 1974) as the indicator of health. It is high on the Great Lakes food chain; it concentrates persistent toxic substances, and it lives as a breeding adult throughout the year in the Great Lakes basin eating contaminated Great Lakes fish. It should continue in use as a long-term monitor of trends in levels. But it is extraordinarily insensitive; even though it accumulates high levels of chemicals, it will still go through courtship, build a nest, lay fertile eggs and incubate them. Though embryonic mortality will be high, some of the highly contaminated eggs will still develop and a few may even hatch out under these adverse conditions. The Herring Gull is useful for demonstrating toxicological injury (Gilbertson 1983) under conditions of substantial contamination as occurred in the early 1970s but it is not the species to use as an indicator of the level of restoration needed. By the time the Herring Gull is into and out of trouble, many other more sensitive species will be locally extinct.

One of the tenets of pollution ecology is that when a plant or animal community is exposed to a toxic chemical, the community will become simplified (Woodwell 1970). The Great Lakes comprise large assemblages of plants and animals that have been exposed for about forty years to high levels of a variety of toxic chemicals. During that time certain sensitive species must have been seriously affected and some may even have become locally extinct. Thus the second end that should be articulated in restoring the Great Lakes is for rehabilitation of water quality to a degree at which historically affected species are able to re-establish, survive and to reproduce normally.

The following four species, indigenous to the Great Lakes basin, have been shown to be highly sensitive to pollution by persistent toxic chemicals: Bald Eagle *Haliaeetus leucocephalus*, Osprey *Pandion haliaetus*, Mink *Mustela vison*, and Otter *Lutra canadensis*. A little work has been done on Mink and Otter to establish levels of contaminants in the various Great Lakes populations (Proulx, et al., 1985; Foley et al. 1988). Populations close to Lake Ontario and Lake Michigan have all but disappeared even though suitable habitat still remains. Though these species are difficult to study intensively, some scientifically defensible data relating population status to persistent toxic chemicals have been compiled on European Otters, *Lutra lutra*, using presence or absence of the highly characteristic spraints (otter scats) and chemical analytical techniques (reviewed in Mason and Macdonald 1986). Data on Great Lakes populations of Otter and Mink could be compiled on an extensive basis using amateur naturalists. In addition, carcasses can be easily obtained for chemical residue analysis through collaboration with trappers' associations. It is essential, in making a case for restoration, that the historical distribution of the Otter and Mink should be established. These data could be readily compiled from records of the provincial and state ministries of natural resources.

During the period of seriously elevated levels of persistent toxic substances in the Great Lakes most of the Bald Eagle (Sprunt et al. 1973) and Osprey populations were exterminated (reviewed in Bird 1983 and Gerrard and Ingram 1985). A few remnant pairs of Bald Eagles have persisted around Lake Erie but for a long period of time failed to breed (Weekes 1975). The combination of declining residue levels and re-introduction of Bald Eagles to Long Point resulted, in 1986, in five pairs, four of which successfully brought off young, nesting on the north shore of Lake Erie (Paul Prevett, personal communication). Similarly, in the Apostle Islands in Lake Superior, Bald Eagles have successfully re-established themselves and, where they refrain from eating Herring Gulls, reproduce successfully (Kozie 1986; see also Madsen et al. 1982). Seemingly less is known about the Osprey but the experience in Connecticut demonstrates that, where and when residue levels decline, populations re-establish themselves and reproductive success returns to pre-contamination levels (Spitzer et al. 1978). Again, the historic distributions could be established from nest record schemes, museum egg collections and naturalists' notebooks. The

advantage of the Osprey is that it can be readily manipulated by establishing artificial nesting platforms (reviewed in Bird 1983). Structural work and record-keeping could be undertaken by naturalists' clubs. The Bald Eagle is more difficult to provide for; however, it has the advantage that it is not only classified as endangered but also is an official symbol of the United States.

These four species are top line predators formerly distributed throughout the Great Lakes ecosystem. When water quality objectives were being developed for various persistent toxic substances, it was concluded that a level of 0.001 micrograms per litre was adopted for polychlorinated biphenyls in water should not be exceeded so that fish tissues should not exceed 0.1 micrograms per gram to protect wildlife populations. The published value (IJC 1975) was accompanied by the caveat that "this level may not be adequate to provide protection to certain predators". Thus there is an explicit uncertainty as to whether attainment of compliance with this water quality objective would be a sufficient means necessary to attain the ends of satisfactorily restoring the Great Lakes. Acceptance of these four species, and particularly the Bald Eagle, as indicators of ecosystem health could supply tangible ends for restoration of the Great Lakes so that pragmatic engineers and politicians would be prepared to spend further billions for more stringent clean-up of releases of persistent toxic chemicals. This goal could provide the catalyst for the final stringent clean-up required not only to protect a national symbol but also human health and future generations.

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John Richardson: Deserving of Greater Recognition

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Houston, C. Stuart. 1988. John Richardson: Deserving of greater recognition. *Canadian Field-Naturalist* 102(3): 558–563.

Contributions of Sir John Richardson to Canadian ornithology include six currently accepted species and 10 subspecies, but Joseph Sabine and William Swainson have received much of the credit that should rightfully be Richardson's.

Key Words: John Richardson, William Swainson, history of Canadian ornithology.

Three recent books on bird names (Choate 1973; Leahy 1982; Terres 1980) give appropriate space to William Swainson and to John Franklin, who led the two Arctic exploring expeditions on which John Richardson was surgeon and naturalist. All three fail to mention John Richardson, who spent nearly eight years in what is now Canada and made major contributions to its natural history. Why does Richardson's name no longer merit mention?

Richardson's bird specimens from the first Franklin expedition of 1819–22 were described by Joseph Sabine, who thereby received credit for three new taxa (Sabine 1823). After the second Franklin expedition (1825–1827) Richardson wrote a fine 32-page introduction to and almost every useful sentence in the species accounts of *Fauna Boreali-Americana, Volume 2, The Birds* (hereafter, simply *The Birds*), but he allowed the name of Swainson, his artist, to be placed in front of his as senior author (Swainson and Richardson 1832). Several of the scientific names attributed to Swainson were certainly coined by Richardson. A delay of more than two years in publication, caused by Swainson's attempts to force classification into a Quinarian System (Rennie 1833), allowed prior description of two new species also collected by Richardson. How did such miscarriages occur? My perusal of the original holograph diaries of John Richardson (Houston 1984), Robert Hood (Houston 1974) and George Back (C. S. Houston, mss.), the three naval officers of the first Franklin expedition, and of one major portion of Richardson's extant correspondence, now allows me to provide most of the answers.

1. Sabine's descriptions:

Bird and mammal specimens collected by Richardson and Hood at Cumberland House (53°58'N, 102°16'W), in 1819–20, and by Richardson at Carlton House (52°52'N,

106°32'W), from 10 to 26 May 1820, were sent to York Factory by canoe with the Hudson's Bay Company furs. When the 12 species of mammals and "above 40 species of birds" reached England, they were given by the Earl of Bathurst, secretary for war and the colonies, to Joseph Sabine, the inspector-general of taxes and an honorary secretary of the Horticultural Society, who had a large collection of British birds. Bathurst requested that Sabine "prepare a scientific description of the different specimens, and communicate the same to the Linnean Society," and then place the specimens in the British Museum (Sabine 1822). It was unusual for Bathurst, even with the accepted standards of his day, to request one naturalist to prepare for publication the work of another, before the latter had returned from the expedition.

On 15 January 1822 Sabine presented before the Linnean Society of London a review of the "Marmots of North America", with a description of three new species of ground squirrel. His paper was in press when Commander Franklin¹ returned from arctic North America. Franklin insisted that Sabine append the following note in proof: "October 29, 1822, Captain Franklin, who returned in the present month, whilst the preceding pages were printing, having intimated his desire that an account of the subjects of Natural History collected by him during his expedition should accompany the narrative which he is preparing for the press, the descriptions of the collections alluded to at the commencement of this paper will form a part of that publication."

Thus Joseph Sabine, who had already invested much time and effort in studying Richardson's specimens, came to prepare Appendix V, the Zoological Appendix (Sabine in Franklin 1823). In addition to the North American subspecies of Black-billed Magpie, *Pica pica hudsonia* Sabine, he received credit for describing Wilson's

Phalarope, *Phalaropus wilsonii* Sabine; the specimen of the latter from Cumberland House was the first or "type" specimen until 1884 when Vieillot's 1819 description from Paraguay, with the specific name of *tricolor*, was recognized to be of the same species. Sabine also recognized that the small, black-headed gull from the Saskatchewan River had appreciable differences from the "Laughing Gull"; in *The Birds* it was named Franklin's gull, *Larus franklinii* Richardson.

Descriptions of birds in Richardson's diary, and most specimens obtained in 1821 and 1822, were not made available to Joseph Sabine, probably because Richardson under the circumstances chose not to share them with Sabine. Richardson collected a new species of sandpiper at York Factory on 29 July 1822, naming it tentatively in his field notebook, *Tringa hemipalma douglasii*. When published in *The Birds* as *Tringa Douglasii* Swainson (Swainson's name once again was given as authority for a name coined by Richardson), it was six years too late; Charles Lucien Bonaparte had gained priority by naming the Stilt Sandpiper *Tringa himantopus* in 1826 in the *Annals of the Lyceum of Natural History of New York*. Richardson's meticulous description of the Yellow-billed Loon at Fort Enterprise on 1 November 1820 did not appear in print for 164 years (Houston 1984); meanwhile G. R. Gray had named the species *Colymbus adamsii* (now *Gavia adamsii*) in August 1859.

Also withheld from Sabine were watercolors painted at Cumberland House in 1819–20 by Richardson's assistant, Robert Hood, of four species not yet described to science — Black-backed Woodpecker, *Picoides arcticus* (Swainson); Yellow-headed Blackbird, *Xanthocephalus xanthocephalus* (Bonaparte); Hoary Redpoll, *Carduelis hornemanni* (Holböll); Evening Grosbeak, *Coccothraustes vespertinus* (Cooper). These paintings were first published more than 150 years later (Houston 1974). Another specimen of the Black-backed Woodpecker, collected in the Rocky Mountains northeast of Jasper by Thomas Drummond, Richardson's assistant on the second Franklin expedition, became the type for *Picoides arcticus*. (Incidentally, a typographical error, giving the location as 57° north latitude, has been repeated by AOU Check-lists ever since; careful scrutiny and retracing by air of Drummond's itinerary has shown the location as 54°.)

2. Richardson-Swainson correspondence:

The letters received by William Swainson fill two large volumes in the Linnean Society Library,

Burlington House, Piccadilly, London, England. From these it is apparent that as early as 28 July 1828, Swainson was involved with Richardson in preparing *The Birds*. On that date John Franklin told Swainson that he had contacted Nicholas Garry, the Deputy Governor of the Hudson's Bay Company "mentioning your wish to compare the birds in the collection of that Company with those which were brought home by Dr. Richardson." By 17 December 1829 Swainson had submitted 19 of the eventual 50 bird paintings for *The Birds*, as acknowledged by Edward W. Dundas on behalf of publisher John Murray.

Richardson's sound medical background in Latin placed him at some advantage over Swainson. Appended to his first extant letter to Swainson on 18 June 1829 were Richardson's "names of Finches: names for the bird with the streaked head." In seeking a scientific name for a new species which he called the White-crowned Finch, Richardson engaged in what we would now call "brain storming" as follows:

Zonocorypha belted crown of the head
Grammocorypha lineated crown of the head
Grammophoros line-bearing
Grammocorus or *Grammopeles* lineated helmet
Zonocorus belted helmet
Grammocranos lineated head
Grammocephalus the same nearly
Zonothrix belted hair or scalp
Grammothrix lineated hair or scalp

The compounds from *gramma* or *grammodes* (a line or like a line) are more appropriate than those from *Zona*, a belt, because the latter is less seldom applied to stripes of colour, but *Zonocorphyia* or *Zonothrix* perhaps sound better than the other."

Richardson's next letter to Swainson on 8 September commiserated with him on what he considered underpayment to his artist-collaborator: "I shall return to London within a fortnight and will then transmit to you the balance of the £300 for the plates. I feel much obliged to you for the anxiety you have expressed and the exertions you have made to render the illustrations of the work more beautiful — and am sorry that the smallness of the sum allotted by Government should deprive you of all compensation for the labour you have bestowed on the drawings for the wood cuts. As to your literary labours on this work I am afraid that your only rewards will be fame & the pleasure of having promoted an agreeable & useful science. Works on Natural History very rarely in this country & I believe seldom in any other, bring money to the authors." On reading the correspondence, one gets the feeling that

Richardson's later placing of Swainson's name ahead of his own may have been a partial recompense, offering recognition in place of money.

On 24 September Richardson forwarded a draft for £62.11/6 and requested that Swainson give him "a note of the names of the species in the order in which you think they ought to be arranged." The next, undated letter mentioned that the printer "would shortly need copy."

On 5 December 1829 Richardson still considered himself the first author of *The Birds*, sending Swainson "the rough manuscript of the account of the Falcons for your inspection and opinion," adding, "I endeavoured to incorporate your notes with my own observations but without success as in detailing the habits of the birds I have been accustomed to speak in the first person . . . I have therefore except in a few instances introduced them [Swainson's taxonomic discussions] as a quotation from your correspondence — at the same time I am desirous if you think it necessary to mention even more strongly than I have done in the introduction to the first part the general assistance you have rendered me by naming the species & giving the synonyms." (In *The Mammals*, 1829: x, Richardson said: "William Swainson, Esq. . . . undertook to arrange and make drawings of the Birds, elucidate the Synonyms, furnish Remarks on the natural groups, and, in fact, to charge himself with the principal part of the Ornithology.") In the same letter, Richardson explained why he wrote extremely detailed descriptions of each specimen: "In the descriptions of the species I have perhaps been unnecessarily minute, but in reading the older writers, the briefness of their descriptions seem to be the chief cause of the confusion of synonyms, especially as they have seldom noticed how each species recedes from the generic type."

Richardson, hiding his impatience, continued to be unfailingly polite to Swainson, whose delays were holding up publication. On 24 March 1830 Richardson hoped ". . . that you will be able to furnish me soon with all your general remarks on the land birds without much inconvenience to yourself — as I think it desirable on every account that the work should be published as speedily as possible." In this letter Richardson suggested for the Rosy Finch the name of "*Spadophrys* (gray-crowned) or *Tephrocotis* (gray-coloured on the hind-head)," adding: "The latter is most applicable." Richardson resumed this discussion on 16 November: "As you left a blank for the sub-generic name of one of your divisions of *Fringillae*, I have inserted *Leucosticte*

which is a Greek termination adopted into the Latin & perhaps preferable to *Leucosticta* (White-streaked & also pied). I have also used *tephrocotis* grey-crowned for the new species of *Linaria* which can be readily changed when you revise the sheets if you have any other name in view." Clearly Richardson coined the currently used name, *tephrocotis*, which was reduced to subspecific status, *Leucosticte arctoa tephrocotis* (Swainson), in the sixth AOU Check-list.

On 4 April 1830 Richardson wrote "I am glad to learn that you have so far advanced in your general remarks and observations and that they are so copious. They cannot fail to be highly interesting and useful to the Ornithologist." On 13 April Richardson sent Swainson the first proof sheet of *The Birds* and asked Swainson's opinion concerning the subgenera of owls. On 1 June Richardson forwarded proofs of the wood cuts (made from 41 of Swainson's black-and-white drawings to illustrate parts of various birds; these were in addition to the 50 paintings). On 13 June Richardson corrected the last syllables of two of Swainson's species' names to agree with the gender of the genus.

On 5 October, Richardson wrote: "I am now very anxious that our work should be brought to a close not only because the delay encreases [sic] the expence [sic] to the publisher . . . but also on Mr. Kirby's account. That gentleman has long been prepared with his descriptions of the insects but Murray refuses to listen to any proposition about printing that part until he sees how the ornithology sells . . . This however cannot be agitated until I can lay the first & second parts complete before the Treasury with our account of the expenditure for them. I mention these matters now to explain my reasons for hurrying you, which I would not do knowing your other engagements, if the delay of our work coming out affected myself only." Richardson also told of sending Professor Jameson the proof sheets to use in Jameson's reprint of Alexander Wilson's *American Ornithology*, publication of which was also delayed by waiting for Swainson to decide on Latin names. (Jameson's book used some of Richardson's names and ascribed them to Richardson. An example is *Lagopus leucurus* Richardson, the White-tailed Ptarmigan.) As a postscript, Richardson modestly advised Swainson, ". . . I do not wish my name to be given to any of the species in future. I feel that it has been already too often repeated in works in which I have been concerned. . . ."

On 24 October Richardson suggested some more generic names to Swainson: "*Leucocoma*

means white-haired, *leucosticte* white-streaked, *leucopsis* or *leucopsia* white-faced, *leucopareia* white-cheeked. *Zonotrichia* may possibly be a better generic name than *Zonothrix* which is an adjective. . . ." From these suggestions, Swainson accepted and has received credit for, both *Leucosticte* and *Zonotrichia*.

In the same letter, Richardson's caution in accepting new species was well ahead of his time: "While I was in Edinborough I saw Douglas' specimens of the Grouse — *Tetrao urophasianellus* is scarcely a variety of *T. phasianellus* [Sharp-tailed Grouse]. *T. sabinii* is the *T. umbellus* [Ruffed Grouse] in autumn plumage. *T. franklinii* is one you have figured & which Bonaparte considers to be a variety of *T. canadensis* [Spruce Grouse]. *T. richardsonii* is I believe *T. obscurus* [Blue Grouse]." Though David Douglas (1829) named each of these as full species, all have since been relegated to subspecific rank as Richardson wisely suggested.

On 31 October Richardson wrote to Swainson, who was then a patient of the well-known physician Dr. Peter Mark Roget (still a household name because of his *Thesaurus*): "I am truly sorry to learn the bad state of your health. The symptoms you mention are probably to be attributed to over application & want of exercise but you can have no need of my advice while you have so able a physician as Dr Roget. . ."

Richardson's excessive modesty appears to have been a second reason for placing Swainson's name ahead of his. On 2 November he wrote: "In the introduction to the first volume, I stated that I could not without assistance do justice to the Ornithological department and I felt this so strongly that I would gladly have entrusted the whole of that part to you or to any other able ornithological [sic] who had leisure for the task, as I did Insects to Dr. Kirby and the Plants to Dr Hooker. You informed me, however, at the outset that you could not undertake more than the synonyms and general remarks without a compensation for your time which I had no means of providing. I feel grateful that you have devoted so much more time to the subject than I had any reason to expect, and still more for the desire you evince even under the pressure of ill health to render the work interesting to zoologists." On the other hand Richardson objected strongly to Swainson's rewriting of his descriptions of specimens:

"But while one half of the volume is printed in its present form I should be wanting in justice to myself were I to agree that the other half should be

so drawn up as to contrast throughout with the parts I have executed in the preceding pages. I should be vain indeed were I willingly to hazard such a comparison, with the concise descriptions of an able and veteran ornithologist — neither could I without subjecting myself to ridicule associate my name with yours on the title page, when beyond the first fifty birds there would be but a very few words that I could call my own." Richardson in the same letter showed that he could not comprehend Swainson's attempts to force bird classification into the Quinarian System: "I am unable to say what is typical, what not, or upon what parts your remarks may hinge."

Although it was ascribed to Swainson alone in the *Second AOU Checklist*, on 3 January 1831 Richardson suggested another new generic name: "*Scolecophagus*, worm eater, is the generic name I would suggest for *Quiscalus ferrugineus*." [Rusty Blackbird].

Richardson first recognized that nighthawks merited recognition as a separate genus and coined the name *Chordeiles*, still in use today, although credited to Swainson. In his letter of 20 February, Richardson wrote, "Chordeiles or 'harp-string of the twilight' is the subgeneric name I would suggest for *Cap. virginianus* — an allusion to the peculiar noise it makes in the air like the base string of a harp."

On 13 March Richardson took Swainson to task for concocting a bad generic name: "*Sylvisoma* I think better than *Sylviasoma*, but neither are good as being compounded of Greek & Latin which I believe is held to be inadmissible." Swainson therefore changed his generic name for the Yellow, Magnolia and related warblers to *Sylvicola*, now merged within *Dendroica*.

On 13 April Richardson's generosity was again evident: "I observe in correcting sheet 23 you have inserted Rich instead of Sw in the title *Tetrao (Lagopus) leucurus*. I had intended to put your name to all the species that are new, not that I had not suspicions of some of them being undescribed, but I thought that you properly determined the species by your revising of the synonyms & comparisons &c. In this case also the adoption of the sub-genus (*Lagopus*) requires your name to the species, respecting which I have done nothing but suggest the name *Leucurus*. In the same way I have put your name to the species of Gulls &c which you pointed out to be distinct although you have not written remarks on them, but your trouble in comparing them was the same. If you do not like to consider yourself answerable for the proposal of those species you may substitute my name, but

otherwise I think yours had better remain as being of authority & therefore more likely to ensure their adoption by ornithologists. . . *Chordadeiles* — which you have allowed to stand — I have contracted to *Chordeiles*.”

On 13 May “the printer has now all the Mss of the descriptions with the exception of about half a sheet which I cannot send until I receive the description of the Cormorant which I left with you.” On 29 June Richardson had “sent the principal part of [his] introductory chapter to the Printer — and also a set of proof sheets to Jameson”. On 14 October 1831 he at last reported “*The Fauna* is I believe nearly ready for publication . . . all the errors of the press which I could detect have been noticed on the last page of the work.” Due to the delays caused by Swainson, *Fauna Boreali-Americana*, vol. 2, *Birds*, did not appear in print until February 1832 — although the date of 1831 is given on the title page.

In the preface, Swainson accepted responsibility for the delay in publication: “I feel that some apology is due . . . Whatever blame may be attached to this delay, must fall exclusively upon myself, as Dr. Richardson’s portion has long been prepared. But my desire repeatedly to revise the groups, and submit their contents to many and diversified tests, . . . has occupied no inconsiderable portion of two years; while impaired health, and the necessity of prosecuting literary engagements previously made, have all contributed to retard the publication.”

The delay in publication beyond that stated on the title page was not at first appreciated in deciding priority of descriptions. When it was, *Larus franklinii* Richardson, accepted by the AOU until 1922 (Oberholser 1922), lost its priority to Wagler’s specimen from Mexico, published in *Isis von Oken* in May 1831. Similarly the Double-crested Cormorant was known as *Phalacrocorax dilophus* (Swainson) in the first two AOU Check-lists until it was realized that Lesson’s name of *auritus* in *Traite d’Ornithologie* on 11 June 1831 took precedence. Since Lesson’s locality of “New Zealand” was clearly in error, the “type locality” remains credited to the Saskatchewan River, based on Richardson’s specimen.

Richardson tended to be a “lumper”, not a “splitter”. Bonaparte in 1838 recognized the “Common Buzzard”, *Buteo vulgaris*, collected by Richardson at Carlton House, as a new species, which he named Swainson’s Hawk, *Buteo swainsoni*. Bonaparte at the same time named the Boreal Owl from Carlton House, *Nyctale richardsoni*, now the subspecies *Aegolius funereus*

richardsoni (Bonaparte). Bonaparte’s brief list referenced the appropriate plate in Audubon for every North American species, and Audubon’s paintings of the Swainson’s Hawk and Boreal Owl were based on specimens from Columbia River and Bangor, Maine, respectively. In this way, these localities, rather than Carlton House, became recognized as the type localities for those taxa.² Similarly, Ridgway in 1870 recognized the Merlin from Carlton House as a new taxon, now the subspecies *Falco columbarius richardsonii* Ridgway, but used his own specimen from the mouth of the Vermilion River, South Dakota, for his description. Although vernacular names for subspecies have been discouraged since the fifth AOU Check-list, “Richardson’s Merlin” persists in common use for the easily recognized pale prairie form, but “Richardson Owl,” though used by authors such as Macoun and Macoun (1909), is rarely heard now.

Richardson evidently was an unusually modest man, considering his accomplishments. On his first visit to North America in 1819–22, he was already a talented lichenologist, botanist and mammalogist. By the time of his second and major collections in 1825–27, he had become a skilled ornithologist as well — one of the most well-rounded naturalists to set foot in North America. That he was a good field ornithologist as well as a collector of specimens is evident from the remarkably accurate ranges listed in his 12-page table of North American bird species, and by AOU Check-list recognition that he collected the first or “type” specimens for the following:

SPECIES (6):

- Trumpeter Swan, *Cygnus buccinator* Richardson [Hudson Bay]
- White-tailed Ptarmigan, *Lagopus leucurus* (Richardson) [Rocky Mountains, 54°]
- Forster’s Tern, *Sterna forsteri*, new name given by Nuttall for *Sterna hirundo* Richardson [Saskatchewan River, 30 miles west of Cumberland House, Saskatchewan]
- Olive-sided Flycatcher, *Contopus borealis* (Swainson) [Carlton House, Saskatchewan]
- Clay-colored Sparrow, *Spizella pallida* (Swainson) [Carlton House]
- Smith’s Longspur, *Calcarius pictus* (Swainson) [Carlton House]

SUBSPECIES (10):

- [Canada Goose], *Branta canadensis hutchinsii* (Richardson) [Melville Peninsula]
- [Black Scoter], *Melanitta nigra americana* (Swainson) [Hudson Bay, 57°]

[Mew Gull], *Larus canus brachyrhynchus* Richardson [Fort Franklin, Great Bear Lake]
 [Hairy Woodpecker], *Picoides villosus septentrionalis* (Nuttall) [Carlton House; listed by AOU as Saskatchewan River]
 [Black-billed Magpie], *Pica pica hudsonia* (Sabine) [Cumberland House]
 [Varied Thrush], *Ixoreus varius meruloides* (Swainson) [Fort Franklin, Great Bear Lake]
 [Swainson's Thrush], *Catharus ustulata swainsoni* (Tschudi) [Carlton House]
 [Loggerhead Shrike], *Lanius ludovicianus excubitorides* Swainson [Carlton House]
 [Rufous-sided Towhee], *Pipilo erythrophthalmus arcticus* (Swainson) [Carlton House]
 [Rosy Finch], *Leucosticte arctoa tephrocotis* (Swainson) [Carlton House]

Canadians should remember that Richardson provided us with pre-settlement data on the natural history of our northwest, equal to that available for any other portion of North America at that date.

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Footnotes

¹Lieutenant Franklin learned of his promotion to Commander, retroactive to 1 January 1821, on 7 December 1821, four days before he reached Fort Providence, Great Slave Lake. His commission as Captain was dated 20 November 1822, about a month after his return to England. Sabine was correct in giving Franklin the rank of Captain, even though this was not yet his rank on the date of the note!

²Bonaparte said, "Throughout the list, I have quoted as Types of the Species under consideration, the figures of the great works of Mr. Gould and M. Audubon on the Ornithology of the two regions, as they must be considered the standard works on the subject."

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A Tribute to Austin Loomer Rand, 1905–1982

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Austin Loomer Rand's ornithological career began in Nova Scotia and eventually touched most parts of the world. He was born in Kentville on 16 December 1905 but lived most of his formative years in nearby Wolfville.

As a youth he showed unusual talent as a naturalist and it was inevitable that he soon came under the guidance of Robie W. Tufts who lived in Wolfville also. Indeed Rand was the first of a long succession of young people who were aided by Tufts and who went on to successful careers in the natural sciences. In fact, Tufts was able to influence Rand to seek a professional career in ornithology even though this was contrary to the wishes of Rand's father. Accordingly, he received a B.Sc. degree from Acadia University in 1927 and went on to Cornell University for a Ph.D.

Austin and I both grew up in Wolfville but he was a little older and he left home before I got to know him very well. However, I well remember meeting him one early autumn evening as he was returning from an all-day hunt on the Grand Pré marshes, near Wolfville. An impressive figure indeed, all six-feet-six of him, high rubber boots slapping against each other with each long stride, double-barrel shotgun on his arm, binoculars superincumbent on a long string of mixed game bird specimens draped over his shoulders.

He was big and rugged and he learned early how to find his way about the Nova Scotia countryside. Once, after the seasonal closing of a summer boy's camp he had been attending deep in the forested interior of western Nova Scotia, he decided to return home on foot. Taking a compass course over some 120 km of heavily-wooded terrain, swimming rivers and lakes where necessary, rafting his backpack on logs, he reached home without incident.

When Austin was a youth in Wolfville hunting was more widely condoned than it is today, and bird watching was not very highly regarded as a productive occupation. He once remarked facetiously that he carried a shotgun "as evidence of respectability".

In 1929, while he was still a graduate student at Cornell, a strange twist of fate brought about what

was doubtless the most significant opportunity of his career. An expedition to Madagascar was being organized jointly by the three major museums in New York, London, and Paris. C. G. Harrold, a promising Winnipeg naturalist (Cartwright and Lawrence 1929) had been engaged as a member of the expedition to collect specimens of birds. While in New York preparing for the expedition, Harrold was fatally stricken with meningitis. On the recommendation of Dr. A. A. Allen, Professor of Ornithology at Cornell, Rand was selected to fill the vacancy.

Thus, early in his career, Rand was given a golden opportunity to demonstrate his capabilities. He made the most of the chance by distinguishing himself so brilliantly that, when the expedition was over, he was chosen to write up the ornithological results and this became the thesis of his Ph.D. It was published as a volume of *Bulletin of the American Museum of Natural History* and it remains today the most important work on the fascinating avifauna of Madagascar.

The American part of the Madagascar project was financed by the Archbold family and young Richard Archbold was a member of the expedition. In the course of the expedition, a friendship was formed between Rand and Archbold which was destined to be a lifelong one. When, in the 1930s, young Archbold financed three extremely important expeditions to New Guinea, he chose Rand as co-leader and ornithologist. Later Rand researched and published the rich ornithological results of all three.

In 1941, Richard Archbold founded the Archbold Biological Research Station, near Lake Placid, Florida. Rand assisted importantly in its organization and was employed to do research there. Although he worked at the station for only a short time, he maintained close contact with the institution for many years until Archbold's death in 1976, serving as a research associate and trustee.

Library and research facilities were limited at the new Archbold station. In 1942 Rand resigned from his salaried position there and moved to Ottawa to accept a position as Assistant Zoologist at the



Austin Loomer Rand portrait taken at Ottawa, 1946. Courtesy National Museum of Natural Sciences (Photo Retrieval Section, Library, with special thanks to Cris Kirby).

National Museum of Canada. When he arrived, the Museum was in a period of wartime retrenchment. Space in the Victoria Museum building was at a premium, most of it taken over by other government departments. The bird exhibits were closed to the public. The bird research collection and offices were squeezed into the erstwhile exhibition space. Temporary walls (formed mostly of specimen cabinets) served the dual purpose of enclosing the ornithology offices and collections, and concealing the inactive exhibits. The inconvenience did not bother Rand. With the research collections, files, and a good library still available, he quickly began what was to be an extremely impressive work output. As Assistant Zoologist, he worked with ornithologist P. A. Taverner and mammalogist R. M. Anderson, dividing his time about equally between birds and mammals.

The wartime construction of the Alaska Highway and the Canol Road opened up access to previously unknown faunal areas in the northwestern mainland of Canada and Rand was quick to take advantage of the opportunity to explore them. He spent the summer of 1943 studying the birds and mammals along the new southern half of the Alaska Highway and in 1944 he worked the Canol Road. His third and last field season for the National Museum of Canada was in southern Alberta in 1945.

His field notes are copious and they reveal much about the man, his tremendous enthusiasm, broad interests, and quiet sense of humor. While observations of both birds and mammals make up the bulk of his diaries (in about equal proportions), there are comments on the weather, fishing, people (sometimes vividly characterized), daily incidents, and the occasional good story. Unfortunately, his diaries were often written in the haste of enthusiasm, in lead pencil, and in handwriting surprisingly small for such a big man, and therefore are frequently difficult to decipher. The following excerpt, dated 16 July 1943 near Trutch, Alaska Highway, illustrates both his interest in experiments in animal behavior and his sense of humor:

"Sitting quietly, I saw a bear coming directly toward me, at 25 yards, apparently following my tracks (I'd rubbed my moccasins on the bear skin at camp). Quietly, without a sound, but nevertheless apparently carelessly, it came straight toward me. At about 20 feet I stood up and spoke to it. (Took off my hat and said "How do you do, Mr. Bear?") It halted, in a moment turned, there was a slight swishing of the alders, and it was gone."

During his six years in Ottawa, Dr. Rand was closely associated with the Ottawa Field-Naturalists' Club. In his Ottawa years he was an active Member of Council, 1st and 2nd Vice-President, and, for a time, Chairman of the Publications Committee. He was especially interested in *The Canadian Field-Naturalist*. Not only was he Associate Editor (ornithology), he was also by far its most prolific contributor on both bird and mammal subjects while he was in Ottawa.

In April, 1946, he was elevated to the post of Associate Zoologist at the National Museum of Canada and, a few months later, to Acting Chief of the Biological Division, a richly deserved promotion. In his short stay at NMC, and despite wartime restrictions, he accomplished a truly enviable work output and created a lasting imprint on Canadian ornithology and mammalogy and on the Museum itself.

In July, 1947, Rand resigned from NMC and moved to Chicago and the Field Museum of Natural History. There he had access to a large world-wide bird collection and he was in his element. After eight years as its Curator of Ornithology, he was promoted in 1955 to Chief Curator of Zoology, a position he held until his retirement. In his 23 years in Chicago, he researched and published over 100 scientific papers on various aspects of birds, numerous popular articles, and four books including *Stray Feathers from a Birdman's Desk* and *Ornithology: An Introduction*. For a fuller account of his career in the United States see Traylor, Amadon, and Godfrey (1984).

Austin was gracious and friendly, always generous in helping others. If his large frame and booming voice tended to seem intimidating, this was quickly dispelled by his easy smile. He was an extremely prolific worker in an extraordinarily broad range of both bird and mammal subjects. He wrote rapidly, his style direct and succinct, avoiding frills and redundancy. His many systematic and faunal publications touched on practically all the major bird taxa of the world and on all major geographical areas. He was also deeply involved in animal behavior, evolution, and ecology.

He was a Fellow of the American Ornithologists' Union and served as its President from 1962 to 1964. He enthusiastically attended the International Ornithological Congresses and was a member of the International Ornithological Committee from 1950 until his retirement. On 9 May 1961, he received an honorary D.Sc. degree from Acadia University, his alma mater.

In 1970, came compulsory retirement at age 65. Austin and his wife, Rheua, settled in Florida, in a house they had purchased several years previously on a little lake close to the Archbold Biological Station.

Austin Rand died on 6 November 1982, only a few hours prior to the death of his mentor, Robie W. Tufts. Both his sons, Dr. Stanley Rand and Dr. William Rand, became professional scientists. They, his widow Rheua, and several grandchildren survive.

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A Canadian Bibliography of Austin L. Rand

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During his employment with the National Museum of Canada (1942-1947) Austin L. Rand produced 49 papers and notes, 36 on Canadian birds and mammals, one on Greenland birds and one obituary as the sole author, and another 11 papers on Canadian mammals in coauthorship. In addition, he authored another 24 Canadian contributions, 5 prior to coming to Ottawa and 19 after he departed. Of the total of 73 items, 44 were on birds, 28 on mammals; 38 appeared in *The Canadian Field-Naturalist*. As well, he contributed 53 notices, comments and reviews, 52 of these to *The Canadian Field-Naturalist* and all but one of them published in 1943-1948.

Key Words: Austin L. Rand, publications, Canadian, birds, mammals.

No comprehensive bibliography of the publications of Austin L. Rand has been prepared to date and we do not attempt one here. However, his 72 contributions to the bird and mammal scientific and popular literature of Canada plus one obituary, 49 during his relatively brief employment (1942-1947) at the National Museum of Canada, gives him a prominent, though often overlooked, place in the history of that institution and in its role in surveys of the Canadian fauna. Similarly, as the majority of his papers in this period (38) were published in *The Canadian Field-Naturalist*, he was a major contributor to its development in that era. Although this may be judged of relatively less importance in the context of his overall career than his publications on Madagascar and New Guinea (four of the latter, as well as three other papers on Florida and Arizona observations, did not appear until 1942-1943, after he arrived at the National Museum of Canada) and his later contributions to World ornithology, the brief Canadian slice of his career is worthy of special notice.

Dr. Rand had published only five notes and papers on Canadian birds and mammals before

1942, but during his 64-month tenure at the National Museum of Canada he produced 38 alone (one of these on Greenland bird specimens in the National Museum and another an obituary) and 11 in coauthorship: 10 with R. M. Anderson and one with P. A. Orkin. (Although some 1947 and all 1948 papers appeared after he left Ottawa, all but the last four in 1948 bear the National Museum address indicating work completed there.) These four and later contributions on Canadian topics were written from the Chicago Natural History Museum. Included are a 1948-1954 series of 12 popular synopses of bird groups published in *Canadian Nature* (the forerunner of *Canadian Audubon* which preceded *Nature Canada*).

In addition, while in Ottawa he prepared a number of partial manuscripts including work on a new *Catalogue of Canadian Birds* (planned to update the Macouns' 1909 volume) and keys and diagnostic species descriptions for a synopsis of Canadian mammals. The latter were updated and used, with acknowledgment, nearly 30 years later in *The Mammals of Canada* by A. W. F. Banfield (1974. University of Toronto Press for the

National Museum of Natural Sciences). Rand also submitted a manuscript report on "Economic Aspects of the Wildlife of the Northwest" to the Lands, Parks and Forest Branch of the Department of Mines and Resources (Canada) and compiled data on mammals and birds for use of the Department of Mines and Resources, Manitoba. Shortly after his arrival in Ottawa, his previous experiences were drawn on to prepare reports for the United States Government on aspects of Madagascar and New Guinea affecting military activities and a survey of bird life in parts of Polynesia for incorporation in a booklet for the United States Army to be edited by the International Committee of Wildlife.

During 1943–1947 Dr. Rand served as ornithology associate editor of *The Canadian Field-Naturalist*. We list separately the 52 reviews and notices individually credited to him (including one on British bird watching correspondence) in the journal (51 while at the Museum) plus one comment in *Bird-Banding* also written at the National Museum of Canada. Some of these are no more than a single sentence summary, others are longer, reflective reviews, but together they convey a breadth of interest and apparent conviction that *The Canadian Field-Naturalist* should note for naturalists not only books but also some of the research papers published elsewhere, as many publicize contributions in other, particularly Canadian, journals.

Rand, A. L.

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1929. Birds on board ship between Nova Scotia and New York City. *Auk* 46: 246–247.
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1933. Notes on the mammals of the interior of western Nova Scotia. *Canadian Field-Naturalist* 46(3): 41–50.
1942. On some British Columbia bats. *Murrelet* 23(3): 83–84.
1942. *Larus kumlieni* and its allies. *Canadian Field-Naturalist* 56(8&9): 123–126.
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1943. Some familiar Canadian birds. National Museum of Canada Special Contribution 43–4: 1–15 (mimeographed).
1943. Bats in Saskatchewan. National Museum of Canada Special Contribution 43–5. [Reprinted (1943) in *The Blue Jay* 1(4): 34.].
1943. Saw-whet Owl and food recognition. *Canadian Field-Naturalist* 57(2&3): 35.
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1943. History of the Raccoon (*Procyon lotor* L.) in Nova Scotia. *Canadian Field-Naturalist* 57(3&4): 95.
1943. Bird moves its eggs to new nest. *Canadian Field-Naturalist* 57(4&5): 96.
1943. Canadian forms of the Meadow Mouse (*Microtus pennsylvanicus*). *Canadian Field-Naturalist* 57(7&8): 115–123.
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1944. A northern record of the Flicker and a note on the cline *Colaptes auratus* cl. *auratus-luteus*. *Canadian Field-Naturalist* 58(6): 183–184.
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1945. Green-tailed Towhee, *Oberholseria chlorura* (Audubon) in Saskatchewan. *Canadian Field-Naturalist* 59(1): 44.
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Acknowledgments

Information on Dr. Rand's unpublished work and many of his papers is recorded in the Annual

Reports for 1942-43, 1943-44, 1944-45, 1945-46, 1946-47 (National Museum of Canada Bulletin 112) and 1947-48 (Bulletin 113). We searched also the pertinent volumes of *The Canadian Field-Naturalist*, *The Auk*, and the *Journal of Mammalogy* (the sections in each issue of the latter two of current literature were particularly helpful).

We acknowledge with particular pleasure the interest and encouragement of Arch Stewart and Jean-Guy Brisson of the library of the National Museum of Natural Sciences who searched out sources and references, and of Daniel F. Brunton who contributed a list from the R. M. Anderson collection at the Public Archives, Ottawa (M.G. 30 B40 Volume 15, File 4) of A. L. Rand significant papers through 1945. A. W. F. Banfield. D. F.

Brunton, H. Ouellet, and P. M. Youngman commented on a draft of this manuscript.

Addendum

Another Rand was encouraged to begin his career in Canada and in *The Canadian Field-Naturalist*. A. Stanley Rand has made an extensive and varied contribution to the herpetology literature, but his first published contribution was an addition to the Québec fauna while still a school student in Ottawa.

Rand, A. Stanley. 1944. The Swamp Cricket Frog, *Pseudacris nigrita triseriata* (Wied), in Québec. *Canadian Field-Naturalist* 58(2): 68.

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A Tribute to August Julius Breitung, 1913–1987

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Harms, Vernon L. 1988. A tribute to August Julius Breitung, 1913–1987. *Canadian Field-Naturalist* 102(3): 572–577.

August Julius Breitung, best known for his contributions to Saskatchewan and Alberta floristics, died suddenly of a heart attack on 27 September 1987, at the age of 74, at his Lakewood, California, home. Probably his most notable botanical legacy was the “Annotated Catalogue of the Vascular Flora of Saskatchewan”, a remarkably thorough, detailed and updated (for that time) list of the provincial flora, which even yet has not been superceded. Equally well done were his annotated catalogues of the plants of central-eastern Saskatchewan, of the Cypress Hills, and of Waterton Lakes National Park. In addition, he authored over 20 shorter articles on various plant groups including the native roses of Canada, the willows of Saskatchewan, the buttercups of Saskatchewan, the genus *Rubus* in the Ottawa Valley, the native and cultivated Agaves of southwestern United States, and more recently *Aster conspicuus* in western North America. He collected numerous plant specimens, totalling nearly 20 000 numbers, and over 50 000 duplicates, which have been widely distributed to North American herbaria.

In his botanical career, August Breitung was responsible for publishing one new taxonomic variety, 10 new forms, and 27 new name combinations. At least the following two new species were named in his honor: *Antennaria breitungii* A. E. Porsild, and *Thalictrum breitungii* B. Boivin, as also was the recently described genus *Breitungii* A. Löve & D. Löve [1985. *Taxon* 34(2): 350].

Lacking a formal university education or even a completed high school diploma, August Breitung exemplifies the “self-taught taxonomic botanist”, as well as the consummate “amateur botanist”, since his botanical efforts and floristic contributions were mostly unremunerated. His comprehensive knowledge of native plants and the significance of his taxonomic contributions, belie the distinctions too often presumed between “amateur” versus “professional” botanists. Undoubtedly August was frustrated as a botanist throughout his lifetime to the extent that permanent professional-level employment as a

plant taxonomist was denied him because he lacked the expected collegiate degrees or any formal botanical training.

August J. Breitung was born in Muenster, Saskatchewan, on 9 May 1913, the son of Heronimus and Veronica (Fuller) Breitung, who were recent immigrants to Canada from Germany. In 1924, when August was 11 years of age, the Breitung family, including his two brothers and one sister, moved to a farm near Wallwort P.O., in the McKague area, about 20 miles south of Tisdale, Saskatchewan. August became enthralled with natural history at an early age, observing birds, mammals, insects, and plants. His interest in nature was apparently much influenced by a Wallwort-area neighbor and local naturalist, John (Jack) D. Ritchie. His early fascination with plants is illustrated by an anecdote that when once, as a young boy, August was sent to bring home the cows, he returned with a handful of “posies” but no cows. The Breitung family worked hard to scratch a living from the stony bushland upon which they had settled. Thus it was an achievement for August even to have attended three years of high school at Tisdale by working as a farm laborer for his board and room.

His botanical interests came to the forefront during his high school years, when he collected many flowers and leaves, pressing them between the pages of his school books. In attempting to identify these, he subsequently began to correspond with Prof. W. P. Fraser, a botanist at the University of Saskatchewan in Saskatoon. From Dr. Fraser he received instructions for the proper collecting, pressing and drying of plant specimens, as well as help with plant determinations and an introduction to the available flora-manuals. August later credited Dr. W. P. Fraser with largely influencing his “destiny in botany”. He quickly learned how to collect and prepare plant specimens of the highest quality, and to use effectively the identification keys in available manuals.

For the next decade after leaving high school (i.e. 1933–1943), August continued to live and work mostly on the McKague area family farm. In 1937, the Breitung family moved about 7 miles



August J. Breitung (age 24, on right) with Prof. W. P. Fraser (on left), at campgrounds in Tisdale, Saskatchewan, 21 July 1937 (photo by G. F. Ledingham).



August J. Breitung (age 28), at Breitung family farm home near McKague, Saskatchewan, 1941.



August J. Breitung (ca. age 36), in Ottawa, ca. 1949.



August J. Breitung (age 73) in Lakewood, California, Photo-portrait 23 November, 1986.

northeastward to another farm nearer to McKague. For a period of time, at least in 1941–1942, August resided in Tisdale. Farm labor he did as a necessity, but August's consuming interest was his avocation, botany, which he pursued with the greatest enthusiasm. Not only was he a "voracious plant collector" (his own terminology), but he painstakingly identified and studied all the plants that he encountered, never fearing to tackle even the taxonomically more difficult groups. For help in identifications, he sent numerous specimens to Dr. W. P. Fraser, and subsequently, probably at Dr. Fraser's suggestion, also to different botanical experts. He initiated a correspondence with various provincial, Canadian and American botanists, requesting and exchanging information on plants and plant groups. By the 1940s, August had enlarged his botanical pen circle to include many of the more eminent plant systematists of the day. August must have learned much about plants from these correspondents, and was directed by them to the pertinent plant taxonomic literature. Aided by inputs from his many correspondents, plus his own reading and persistent efforts, he trained himself to become a knowledgeable and capable taxonomic botanist. It is obvious that August had an excellent memory for plant descriptions and a discerning taxonomic eye.

Most of his numerous plant collections of this Saskatchewan period of his life were from the Wallwort-McKague-Dalton area, although many were also from elsewhere in the central-eastern Saskatchewan region, including Bjorkdale, Nipawin, Runciman, Tisdale, and eastward along the C.N. tracks to Hudson Bay Junction. He apparently used a bicycle for even his major botanical collecting forays, although it would hardly seem an appropriate vehicle for conveying the plant presses and other collecting paraphernalia needed for his massive collecting on longer trips. August managed this by collecting plants at one location, drying the plants there, and then posting or freighting them home, before moving on to the next location. During this decade of his life, he made about 10 000 plant collections from east-central Saskatchewan, with duplicates perhaps totalling over 35 000 herbarium specimens.

In the late 1930s, August, in correspondence with Harold A. Senn, Curator of the Canada Department of Agriculture Herbarium (DAO) in Ottawa, offered to exchange sets of his central-eastern Saskatchewan collections. His offer was accepted and during 1939–1942, he sent numerous specimens to DAO. He apparently made similar

offers and sent specimens to Dr. A. Erling Persild, Curator of Botany at the National Museum of Canada (CAN), in Ottawa, to various other large herbaria in Canada and the United States, and even to Dr. Eric Hultén in Stockholm, Sweden.

His well identified and prepared specimens and enthusiastic letters, must have gained the attention of Dr. A. E. Persild, who hired August as an assistant to accompany himself and Dr. Austin L. Rand, an ornithologist, on a Canol Road collecting expedition in the Yukon Territory during the 1944 summer. Then, during the subsequent 1945 and 1946 summers, Dr. Persild rehired August as his assistant on botanical surveys in Banff and Jasper National Parks in the Albertan Rocky Mountains. These botanical expeditions with the National Museum of Canada represented high-points of August's life, and reportedly he was a most enthusiastic and prolific collector who quite impressed Dr. Persild. Several interesting anecdotes arose from these expeditions, one being that toward the end of the 1944 collecting season, Drs. Persild and Rand made a quick trip eastwards on the Canol Road towards Norman Wells, leaving August Breitung to guard the cache of plant and bird specimens that were housed in a movable highway shed. While on their return journey, they were surprised to hear reports that another botanist had recently been collecting in the Mackenzie Mountains, but upon returning to their base, they discovered that the mysterious botanist had actually been August. Dr. Rand, reportedly, was furious that August had jeopardized their summer's collections by leaving them unguarded. But August, still a naive Saskatchewan farm lad, replied simply, "Well, I put a label on the door of the shack saying it was the property of the National Museum and I knew that no one would touch the specimens". Dr. Bernard Boivin, who accompanied them on the 1946 Banff expedition, related that in the evenings while Dr. Persild was organizing his notes and pressing specimens, August would often disappear and presently return to camp with additional great armloads of specimens. It was Dr. Boivin, who many years later in conversation with this biographer, paid August a high compliment with the simple statement, "Breitung knew his plants".

In November, 1946, at the age of 33, August Breitung was hired as an Assistant Technician at the Herbarium of the Division of Botany and Plant Pathology, Canada Department of Agriculture (DAO), in Ottawa, Ontario. His correspondence of the day reveals that he was elated with this position. He finally had a salaried job in the field of

his greatest interest, taxonomic botany, with a large herbarium and a taxonomic library available for use. It seems evident from his correspondence, that this represented a happy and rewarding period of August's life, and he expressed his "hope to now help his fellow botanists a great deal". He began his new job with much ambition and a flourish of activity. His correspondence files show that August was indeed busy with his pen from the time of his arrival in Ottawa, obviously keeping the stenographers equally busy. Within weeks of beginning his new job, he was offering to determine sets of specimens for various collectors over the country, checking herbarium specimen series for others, working up his own collections, requesting loans of specimens from other institutions for his own study, studying and annotating herbarium specimens of various plant groups, and researching his own revisionary efforts. It might be noted that, because of his lack of collegiate degrees or formal botanical training, August had not been hired as a professional research botanist, but at the junior-level of an assistant technician. So most of the foregoing "professional" activities had to be carried on by him in addition to the regular, more routine duties of his job, such as specimen processing, sorting and filing. But throughout his tenure there, it seems obvious that August never allowed his employment as only an assistant technician to prevent him from also playing the role of a taxonomic research botanist in practice.

Upon obtaining employment there, August had his personal herbarium from McKague transferred to the Herbarium of the Canada Department of Agriculture (DAO), in Ottawa, so the latter institution now houses the only full set of his early Saskatchewan collections and many duplicates of these, as well as his Ottawa-period collections.

August spent most of the 1947 summer in the Cypress Hills area collecting plants, compiling habitat lists, and making notes on the flora there. Altogether he amassed about 1500 collection numbers plus duplicates, and accomplished a quite thorough inventory of the Cypress Hills flora, which formed the basis for his eventual publication, "A Botanical Survey of the Cypress Hills". Interestingly, this productive summer's work on August's part apparently had less than favorable approval from his job supervisors, who contended that August had been sent to the Swift Current Canada Agriculture Station only to work under the direct supervision of the range ecologists there who were involved in pasture surveys. Instead, due to an apparent misunderstanding, August transferred himself to work independently in the

Cypress Hills within two weeks after his arrival at the Swift Current Station. Thus, it seems that we can thank a communications problem for one of August Breitung's more important contributions to Western Canadian floristics!

During his tenure in Ottawa, August discovered that the Ottawa River valley contained a wealth of interesting plants new to him, and he proceeded to collect enthusiastically at every opportunity — weekends, holidays and evenings.

While in Ottawa, August met and eventually, on 4 May 1949, married Mathilde Presch, who was a school teacher by training but then working for the Canadian Civil Service Commission. According to August, it was Mathilde who encouraged him to take some night courses in English composition at Carleton University to improve his writing skills, and also urged him to write papers on his botanical research for publication. August remained employed at the Herbarium, Division of Botany and Plant Pathology of the Canada Department of Agriculture, in Ottawa, for about six years, from 1946 to late 1952.

After his Ottawa job ended, August, now age 39, and Mathilde (Tillie) Breitung moved to Glendale, California, in the Los Angeles area, where Mathilde's family lived. Reportedly, he took a temporary job as the supervisor of an apartment building, but August apparently devoted the following 1953 summer entirely to his botanical pursuits without any financial support. He travelled about 1700 miles by car, collecting plants from southern California, northward through Nevada, Utah, Idaho, and Montana, to the Canadian Rockies. During July and August, 1953, August, on his own initiative, conducted a comprehensive survey of Waterton Lakes National Park, securing over 2000 collection numbers plus duplicates. These formed the basis for his eventual 1957 publication, "Plants of Waterton Lakes National Park, Alberta". Job Kuijt (1982), in a frontispiece acknowledgment in his recently published book, *A Flora of Waterton Lakes National Park* (The University of Alberta Press, Edmonton), credited August Breitung with having made "the most significant earlier plant collection in Waterton Lakes culminating in a remarkably detailed catalogue of species", and for first having made known the great botanical wealth of Waterton Lakes.

During his early years in California, August compiled the information and wrote the text for the "Annotated Catalogue of the Vascular Flora of Saskatchewan", which was published in 1957, probably representing his most important

botanical publication. Indicative of its relative significance, is the fact that H. J. Scoggan, in his four-volume *The Flora of Canada* (National Museums of Canada, 1978–1979), cited Breitung's 1957 catalogue of Saskatchewan plants nearly 500 times with regard to plant distributions in that province. At least in present retrospect, it is evident that by the latter 1940s and early 1950s, August Breitung was the most knowledgeable living authority, professional or otherwise, on the native flora of Saskatchewan.

In California, August took a course of study in applied aerodynamics in aerospace technology. For the next approximately 25 years, he worked as an Engineering Draftsman for various companies and research organizations in the Los Angeles area that were contractually involved with aerospace industry, spending much of this time at the California Institute of Technology in Pasadena. But his spare-time botanical interests were not forgotten, although they now turned to plants closer at hand, and in particular to the Agaves of southwestern United States, eventuating in his publication of a monograph on the group in the 1968 Yearbook of the Cactus and Succulent Journal.

About 1970, August took up the hobby of woodworking with the same enthusiastic intensity that he had previously devoted to his botanical avocation. On his lathe, he turned out hundreds of beautiful, high quality wood pieces, including candle-holders, vases, salt-and-pepper shakers, bowls, plates, trays and buttons, as well as some fine furniture. His printing of the scientific name of the wood species on the bottom of most items was a unique feature. In his later years, August was to give many of these wood articles to his friends and correspondents.

August and Mathilde Breitung resided for 23 years at Glendale, California, from January 1953 to 20 March 1976, following which they moved to Lakewood, California, still in the Los Angeles area. About four years later, August retired from his career in engineering drafting.

Following a brief initial post-retirement period of what he referred to as "depression", August reappraised his lifetime achievements and interests. The final five or six years of his life showed a strong resurgence of August's earlier interest in the flora of western Canada and especially of his native Saskatchewan. Having been a prolific letter-writer as a younger man, in his retirement years, August again established an extensive correspondence with various Saskatchewan naturalists and numerous North American

systematic botanists. Since 1982, this biographer personally received a steady stream of letters from August, these often six to 15 pages long, and filled with numerous taxonomic comments, tentative treatments, questions and requests for information, often concerning his own earlier collections. A 3-inch wide correspondence file was accumulated for him during a five-year period. Unfortunately, it proved impossible to keep pace with his letters, due to time constraints and the considerable amount of work often required to adequately research replies to his many questions. Nevertheless, it was always a delight to receive his interesting and informative missives, reflecting his great botanical enthusiasm.

With a surge of ambition, he attempted to catch up on, and personally evaluate, the newer plant taxonomic changes and flora treatments that had been published since the mid-1950s. These opened his mind to innumerable questions and ideas to be discussed with his correspondents and stimulated taxonomic revisionary attempts of his own. August kept busy "researching and writing" because, in his own metaphoric phrases, he was "approaching the twilight of his life" and "wished to make some worthwhile botanical contributions before the sun would sink below the horizon". Some of August's taxonomic "research" methods may have been unorthodox, but present were the essential ingredients of intense curiosity and a desire to learn the truth.

During his earlier retirement years, about once a week August would take the 50-mile bus ride to the UCLA campus to spend the day studying at the herbarium or library. Sometimes he would have become so absorbed in what he had discovered, that, upon returning home, he might stay up nearly all night to study and write to his correspondents about it.

The death of his dearly beloved wife, Tillie, on 20 February 1984, left August a lonely man. August and Mathilde had never had any children. After this, there was a perceptible waning in his exuberance and perhaps a growing awareness of his own mortality, although his keen interest in the flora of Saskatchewan and western Canada continued until the day he died. Increasingly now, he tended to suggest plant taxonomic or distributional questions that he hoped others, rather than himself, would research. Although a retiree of hardly more than modest means, August also began giving a series of donations to the University of Saskatchewan, in three years totalling nearly \$2000 (U.S.), designated to aid field studies and collecting for taxonomic research on the Saskatchewan native flora.

Acknowledgements of his aid, either monetary or inspirational, have appeared in several recently published papers.

By 1986, August appeared to have recovered much of his earlier enthusiasm and optimism, writing as late as January 1987, of being in excellent health and of walking 10 miles a day without fatigue. His letters had again lengthened and once more were filled with innumerable botanical comments, questions and requests. But only a few months later, on 9 April 1987, August suffered a serious heart attack, and his recovery was interrupted by several subsequent relapses. On 9 May 1987, he prophetically wrote, "Today is my 74th birthday. In all likelihood I shall not celebrate another birth date... I am waiting like California is waiting for the BIG EARTHQUAKE ... I hope to be around for a while yet, but I surmise that my days are numbered! But at least, I will be with you in spirit, in the study of Saskatchewan plants". He referred to his heart as working at only 50% capacity, and during the 1987 summer he suffered other associated health problems.

Sunday, 27 September 1987, the day of his death, was one of some excitement and much activity for him, occasioned by a garage sale at his home featuring his many beautiful woodworking articles which had been publicized by a newspaper article in the Long Beach Press Telegram. Neighbors reported that on the morning of that fateful day, August had been in high spirits, pleased with the public response to his sale, and busily meeting people and answering phone calls. His final heart attack was apparently sudden and quickly fatal.

With the passing of August Breitung, we have lost an enthusiastic naturalist and amateur botanist, who, during his lifetime contributed significantly to Saskatchewan and Canadian floristics. But August Breitung's contributions to Saskatchewan and western Canadian taxonomic botany are not yet completed. In a final gesture that revealed the depth of his lifetime interest in the flora of his native province and country, he willed the proceeds of his estate to The W. P. Fraser Herbarium of the University of Saskatchewan, to be set up as the August J. Breitung and Mathilde K. Breitung Memorial Trust Fund, to be used for the support of taxonomic research and publications on the native flora of Saskatchewan. Thus his botanical contributions will continue.

Publications of August J. Breitung

1947. Catalogue of the vascular plants of central-eastern Saskatchewan. The Canadian Field-Naturalist 61(3): 71-100.

- 1951a. The passing of the buffalo. The Blue Jay 9(2): 16.
- 1951b. Carnivorous plants. The Blue Jay 9(3): 20.
- 1951c. The Alaska birch. The Blue Jay 9(3): 20.
- 1951d. Willows of Saskatchewan. The Blue Jay 9(4): 24.
- 1952a. Additions to the plants of Saskatchewan. The Blue Jay 10(1): 20.
- 1952b. Poplars of Canada. The Blue Jay 10(2): 20-23.
- 1952c. Violets of Saskatchewan. The Blue Jay 10(3): 16.
- 1952d. An additional Saskatchewan violet. The Blue Jay 10(4): 23.
- 1952e. Pine Mistletoe. The Blue Jay 10(4): 25.
- 1952f. Common Reed-grass. The Blue Jay 10(4): 25.
- 1952g. Key to the genus *Rubus* in the Ottawa valley. Canadian Field-Naturalist 66: 108-110.
- 1952h. How plants are named. Le Naturaliste canadien 79(1): 5-10.
- 1952i. Native roses of Canada. Le Naturaliste canadien 79(5): 184-188.
- 1953a. Buttercups of Saskatchewan. The Blue Jay 11(1): 20-22.
- 1953b. The vegetation of Saskatchewan. The Blue Jay 11(2): 22-23.
- 1953c. A Letter: Botanizing in California. The Blue Jay 11(4): 18.
- 1954a. A botanical survey of the Cypress Hills. Canadian Field-Naturalist 68: 55-92.
- 1954b. Canadian floral emblems. Canadian Nature 16(2): 42-47.
- 1957a. Annotated catalogue of the vascular flora of Saskatchewan. The American Midland Naturalist 58(1): 1-72.
- 1957b. Plants of Waterton Lakes National Park, Alberta. Canadian Field-Naturalist 71: 39-71.
- 1957c. Vascular flora on the sand dunes at Constance Bay, Ontario. Le Naturaliste canadien 80(3-4): 79-87.
- 1959. Supplement to "Flora of Saskatchewan". The American Midland Naturalist 61(2): 510-512.
- 1964. Cultivated and native Agaves of the southwestern United States. Cactus and Succulent Journal 31: 40 to 36: 139.
- 1968. The Agaves. Cactus and Succulent Journal, 1968 Yearbook.
- 1983. A Letter: Botanizing from afar. The Blue Jay 4(1): 63.
- 1988. Distribution of the Showy Aster, *Aster conspicuus*. The Canadian Field-Naturalist 102(3): 523-526.

Acknowledgments

The author of this biographical tribute wishes to thank William J. Cody and Donald F. Hooper for their kind cooperation in providing much information and access to their correspondence files, the former for also making available August Breitung's correspondence files from when he was at Agriculture Canada in Ottawa, and Mrs. Joyce Dart, sister-in-law of August, for additional background information on his California years.

Received 14 April 1988

Minutes of the 109th Annual Business Meeting of The Ottawa Field-Naturalists' Club: 12 January 1988

Place and Time: Auditorium, Victoria Memorial Museum Bulding, Metcalfe and McLeod Streets, Ottawa, 20:05 hrs.

Chairman: Dr. W. K. Gummer, President

Attendance: About 60 people attended the meeting.

1. Minutes of the Previous Meeting

Barbara Campbell, Acting Recording Secretary, read the minutes of the 108th Annual Business Meeting. It was moved by Roger Taylor (2nd Ellaine Dickson) that the minutes by approved.

(Motion Carried)

2. Business Arising from the Minutes

Bill Gummer noted the following points:

(1) The fee increase recommended in the 1987 report has taken place for 1988.

(2) The Constitution and By-Laws which were recently updated (Janaury 1986) are back for review.

(3) The OFNC computer is now housed in the Beamish building with The National Museum of Natural Sciences. Patricia Narraway is inputing and updating the membership list. We are still looking for a Club office.

(4) The Terms of Reference are being reviewed by an ad hoc group headed by Diana Laubitz.

(5) Roger Taylor congratulated Bill Gummer on behalf of the Club for his work in preparing the *Trail & Landscape* Index.

3. Finance

The Treasurer, Frank Valentine, presented the financial statements. He explained that the finances are handled by three people, but guided by Council and Finance Committee. These three people are Lois Cody, who does the bookkeeping, Bill Cody, who is the Business Manager of *The Canadian Field-Naturalist* and writes the cheques, the Treasurer, who prepares the financial statements. Monty Brigham was thanked for being Auditor.

Frank Valentine noted that all the figures are based on the 30th September 1987. Members Equity at \$76 718 was up from \$71 009 in 1986. Club assets have increased to \$134 315 from \$122 310. Frank Valentine emphasized that 'Equity in the Business' has increased due to good management by Council and the Finance

The Ottawa Field-Naturalists' Club

Balance Sheet as of 30 September 1987

ASSETS

CURRENT	1987	1988
Cash and Term Deposits	\$115 139	\$90 864
Accounts Receivable	12 139	22 981
Accrued Interest	133	120
Prepaid Expenses	1 095	1 105
	<u>\$128 506</u>	<u>\$115 070</u>

FIXED

Equipment		
Less: Accumulated Depreciation	2 461	3 892
Land: Alfred Bog	3 348	3 348
	<u>\$5 809</u>	<u>\$7 240</u>

TOTAL ASSETS	<u>\$134 315</u>	<u>\$122 310</u>
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LIABILITIES, FUNDS AND MEMBERS EQUITY

CURRENT LIABILITIES

Accounts Payable	\$31 819	\$26 280
Deferred Income	10 552	10 485
	<u>\$42 371</u>	<u>\$36 765</u>

MEMORIAL FUNDS

Anne Hanes	841	790
Baldwin	258	258
	<u>\$1 009</u>	<u>\$1 058</u>

OTHER FUNDS

Alfred Bog Protection	\$7 463	\$7 482
Seedathon	1 064	406
	<u>\$8 527</u>	<u>\$7 888</u>

LIFE MEMBERSHIPS	\$5 600	\$5 600
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MEMBERS EQUITY

Balance 1 October 1986	\$71 009	\$74 110
Donations	2 000	1 663
Income over Expenditure for Year		
The Ottawa Field-Naturalists' Club	(306)	1 939
The Canadian Field Naturalist	3 662	(6 717)
Centennial Projects	407	44
	<u>\$76 718</u>	<u>\$71 009</u>

TOTAL LIABILITIES, FUNDS AND MEMBERS EQUITY ...	<u>\$134 315</u>	<u>\$122 310</u>
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Statement of Income and Expenditure
The Ottawa Field-Naturalists' Club
for the year ended 30 September 1987

INCOME	1987	1986
Apportionment of Membership Fees		
Annual	\$12 000	\$12 344
<i>Trail & Landscape</i>		
Subscriptions	391	425
Back Numbers	119	169
	<u>\$510</u>	<u>\$594</u>
<i>Shrike</i> Subscriptions	—	15
	<u>\$12 510</u>	<u>\$12 953</u>
Interest	917	1 781
Total	<u>\$13 427</u>	<u>\$14 734</u>
EXPENDITURES		
<i>Trail & Landscape</i>		
Printing	5 764	4 530
Circulation	352	285
Production	670	1 051
Honorarium	605	605
	<u>\$7 391</u>	<u>\$6 471</u>
<i>Shrike</i> Publishing		88
Committee Activities — Net		
Excursions and Lectures	(945)	(1 702)
Membership	1 389	1 290
Macoun Club	641	363
Conservation	53	57
Birds	69	455
Special Publication	—	987
Special Publication (T & L Index)	285	—
Affiliation Fees	280	325
Baldwin Scholarship	—	150
Office Assistant	495	471
Office Supplies and Expenses	3 949	3 825
Miscellaneous	(39)	15
Computer Charges	219	—
	<u>6 396</u>	<u>6 236</u>
TOTAL	<u>13 787</u>	<u>\$12 795</u>
INCOME OVER		
EXPENDITURES	<u>\$ (360)</u>	<u>\$ 1 939</u>

Statement of Income and Expenditures
The Canadian Field-Naturalist
for the year ended 30 September 1987

INCOME	1987	1986
Apportionment of Membership Fees		
Annual	\$ 8 000	\$ 8 229
Subscriptions	22 195	22 091
	<u>\$30 195</u>	<u>\$30 320</u>
PUBLICATION		
Reprints	7 992	6 447
Plates and Tab Settings	2 733	3 699
Extra Pages	27 593	14 303
Back Numbers	1 388	1 016
	<u>\$39 706</u>	<u>\$25 465</u>
OTHER		
Interest	3 872	7 122
Exchange	2 779	2 543
	<u>\$6 651</u>	<u>\$9 665</u>
TOTAL	<u>\$76 552</u>	<u>\$65 450</u>
EXPENDITURE		
Publishing	\$55 555	\$52 700
Reprints	4 034	5 223
Circulation	4 983	7 130
Editing	2 500	1 701
Office Assistant	3 204	3 051
Office Supplies	640	388
Honorarium	1 974	1 974
	<u>\$72 890</u>	<u>\$72 167</u>
Excess of Income Over		
Expenditure	<u>\$3 662</u>	<u>\$(6 717)</u>

Notes to the Financial Statements
for the year ended 30 September 1987

1. *Authority and Activities*
The Ottawa Field-Naturalists' Club is a non-profit organization incorporated under the laws of the Province of Ontario (1884). The Ottawa Field Naturalists' Club promotes the appreciation, preservation and conservation of Canada's natural heritage; encourages investigation and publishes the results of research in all fields of natural history and diffuses information on these fields as widely as possible. It also supports and cooperates with organizations engaged in preserving, maintaining or restoring environments of high quality for living things. Membership is open to any person or family, upon application and payment of dues. Payment of the Annual Dues as set out in the By-laws will be a necessary condition for the continuance of Membership.
2. *Significant Accounting Policies*
Memberships, subscriptions and donations are recorded as received. All other revenues and expenditures are recorded on the accrual basis.

3. Life Memberships

Life memberships paid since 1977 are recorded at the fee in effect at that time. There are 39 life members.

Auditor's Report

I have examined the balance sheet of The Ottawa Field-Naturalists' Club as at September 30, 1987 and the statements of operations for the year ended. My examination was made in accordance with generally accepted auditing standards, and accordingly included such tests and other procedures as I considered necessary in the circumstances.

In my opinion, these financial statements present fairly the financial position of the Corporation as at September 30, 1987 and the results of its operations for the year then ended in accordance with generally accepted accounting principles applied on a basis consistent with that of the preceding year.

F. MONTGOMERY BRIGHAM, C.A.

Ottawa, Canada
December 1987

Committee. The Club's income is down from \$14 734 to \$13 427 and the expenses are up to \$13 787 from \$12 795. This results in a loss of \$360.

The Canadian Field-Naturalist increased its income to \$76 552 from \$65 450 in 1986. Its expenses increased up to \$72 890 from \$72 167. This resulted in a profit of \$3 662. Income from CFN was up from 1986 because the many extra pages were paid for by contributing authors.

In Frank Valentine's opinion the OFNC is in a sound financial position and according to the Auditor, the books are handled very well. He then thanked Lois Cody, Bill Cody, Monty Brigham, the Finance Committee and Council.

A member asked why September was chosen as the financial year end. Roger Taylor responded that this was to give the Treasurer enough time to prepare a budget, a financial statement and get the Auditor to approve it in time for the Annual Business Meeting in January.

Frank Valentine moved (2nd Frank Pope) to accept the financial statement.

(Motion Carried)

Bill Gummer congratulated Bill Cody on his recent celebration of his 40 years as Councillor and Business Manager of *The Canadian Field-Naturalist* and 41 years as a Club member.

4. Report of Council

The report was read by Bill Gummer and Dan Brunton. After each Committee report there was an opportunity for comments. Bill Gummer noted that we had a very good year and that committees have set goals and have achieved them.

Awards Committee

The 1987 Awards Committee consisted of D. F. Brunton, E. Frankton, W. K. Gummer, P. Hall, D. Laubitz and M. Stuart. The Committee met several times to consider OFNC and external award nominations.

Thirty-four nominations were received for OFNC awards, slightly up from previous years. The Awards Nomination form was found to be helpful to the Committee and to nominators and is being used again for the 1987 awards year. We also considered nominations for members for external awards (such as the Federation of Ontario Naturalists' awards).

The Awards Committee recommended the following individuals for OFNC awards: Honorary Member: (1) Donald E. McAllister (2) Robert W. Nero; Member of the Year — Roy John; Anne Hanes Natural History Award — Clarence Frankton; Service Award — Dorothy Greene, Marc Guertin, Lisa Meyboom, Jim Montgomery and Harry Thomson; Conservation Award — Jane Topping.

These were accepted by Council and were announced at the 1987 Soirée; most recipients were present to accept their certificates. The citations accompanying these awards will be published in a forthcoming issue of *The Canadian Field-Naturalist* and were published in summary form in *Trail & Landscape* 21(4) 1987. The President's Prize winner, selected by President Bill Gummer, was Barbara Martin.

The Committee nominated long-time member Robert Leggett for the Heritage Award of Parks Canada in 1986. He was awarded this honour in February of 1987. Other external award nominations are in process.

A detailed list of all previous OFNC award winners, back to the earliest years of the Club, was prepared by D. F. Brunton and W. K. Gummer. It appears in *Trail & Landscape* 21(5) 236-243 (1987). It identifies, amongst other items, that the OFNC has recognized 63 Honorary Members since 1879, commencing with John Macoun and Sir William Saunders.

In addition, the Committee worked with editor Francis Cook in the development of the tribute to long-time *Canadian Field-Naturalist* Business Manager — W. J. Cody [*The Canadian Field-Naturalist* 101(2) 159-160 (1987)].

The Committee has nominations in hand for the 1987 OFNC awards, as well as for the external honours, and will develop these in the early months of 1988.

D. F. BRUNTON

Birds Committee

G. Pringle (Chairman), T. Beck, M. Benson, A. Cameron, M. Elder, M. Gawn, C. Hanrahan, J. Harrison (Vice-President), R. John (Vice-chairman), B. Ladouceur, D. Perrier, J. Reddoch, C. Rimmer, J. Sankey, W. Smith (Secretary), A. Thompson, D. Toussaint.

The participation of OFNC volunteers in this year's Peregrine Falcon release program was perhaps the most significant activity of the year. Marg Benson is to be commended on her efforts in organizing and scheduling Club volunteers and acting as our chief contact with the Canadian Wildlife Service (CWS) and the Ontario Ministry of Natural Resources (OMNR). Birds

Committee members and the volunteers involved in the program attended an excellent presentation in June where representatives from CWS and OMNR outlined the history and approach in the Peregrine program and discussed general aims and objectives as well as indicating where the volunteers might be of assistance. Marg Benson is presently cooperating with the local program directors in preparing a report that will also be available for publication in *Trail & Landscape*.

Christine Hanrahan coordinated a survey of Loggerhead Shrike breeding locations in eastern Ontario in cooperation with Mike Cadman and the Ontario Breeding Bird Registry. Several Club members participated in this. Unfortunately we do not have a coordinator to replace Christine in the coming year and the future of this project is seriously in doubt. The Breeding Bird Registry is proposing that the project continue and that it be expanded to cover rare species other than Loggerhead Shrikes.

A revised set of terms of reference for the Committee was completed and approved by Council early in the year.

The Bird Status Line completed a successful year of operation despite a forced change of location and phone number. Larry Neily has done a commendable job of operation, striking a balance in content and offering a quality of comment that seems to satisfy our broad constituency. The Rare Bird Alert list has been revised for 1988.

Plans have been finalized for a trial run at providing some food as well as coffee before the Ottawa Christmas Bird Count wrapup meeting. Hopefully we will learn our trade this year and be able to improve next year.

Several boxes of papers were received from Frank Bell's wife and it was agreed to offer them to the National Museum Library, the Department of Agriculture Library and the Macoun Field Club Library, in that order. Joyce Reddoch has been a great help to me in making these arrangements and Christine Hanrahan did an invaluable piece of work in preparing an inventory. The Macoun Field Club graciously agreed to provide temporary storage.

The review of material from the Birds Committee for consideration and eventual delivery to the National Archives has not progressed very far since we had difficulty in determining what materials have already been archived.

As in other years the Birds Committee has coordinated the OFNC winter feeder operation, the fall Seedathon, Spring and Fall roundups and the Christmas Bird Count. Through diligent effort by the concerned members all these activities have been great successes and from the Chairman's point of view, seem to run themselves. A particular note of appreciation goes to our Recent Bird Sightings authors who perhaps have the roughest job of all.

Birds Records Subcommittee: R. John (Chairman), R. Anderson, B. Campbell (Councillor), B. Di Labio, B. Gawn, S. Gawn, J. Harrison (Vice President), B. Ladouceur, G. Pringle (non-voting Secretary), M. Runtz, M. Brigham (alternate), B. Gorman (alternate).

The Bird Records Subcommittee met three times and finalized its terms of reference. It would appear that the new terms have increased this sub-committee's efficiency

allowing it to clear several reports that have been contentious and long delayed in their final resolution. The sub-committee considered 21 reports and found 14 of them to be worthwhile additions to the Club's record base. At the initiative of the sub-committee the Club's photo duplicate collection has been put under the management of Tony Beck who is making changes in the method of storage to prevent long term damage and degradation. Tony is also arranging for significant additions of new material and we believe that in one or two years that the collection will become an important record base. The Bird Records Subcommittee has also recommended a major educational effort in the area of birding ethics and etiquette. Material is being gathered in preparation for a *Trail & Landscape* article.

Without the publication of *The Shrike* newsletter, the level of contribution of data sheets has dropped to a minimal level. I intend to recommend that the few contributors still active stop activity at the end of 1987.

Roy John is preparing a record and list of comments that summarizes the experiences of the Bird Records Subcommittee which were obtained when they prepared the new Ottawa Check List of Birds. This is intended as a resource document for future revisions of the list.

G. PRINGLE

Computer Management Committee

The Computer Management Committee was established in January 1987 to help ensure that the computer assets of the Club are used to meet Club objectives. The original members were Suzanne Blain (Chairman), Barbara Martin, and Ken Strang (OFNC Council liaison).

Initially, we considered how the computer facilities of the Club could be used to benefit the members. We decided the Club would be best served by creating an environment within which members would be comfortable using its computer resources. We spent several months developing policies related to the use of the OFNC computer facilities. In October, the draft policies were approved by Council.

While formulating the policies, we did considerable soul searching on how the Computer Management Committee should operate and what responsibilities it should assume. We identified four major roles for ourselves: (1) Advisor to Council, (2) Controller, (3) Operations Manager, (4) Planner.

As advisor to Council, we reported on software and hardware needs, their projected cost and overall feasibility.

As controller, we acted to safeguard the Club's reputation and its computer facilities (hardware, software, supplies and data) by: (1) requiring that the Club have legal right to use any software it needs and uses; (2) considering (and acquiring, where need be) appropriate service contracts and insurance coverage; (3) ensuring the availability of trouble-shooting expertise; (4) documenting and implementing controlled backup procedures; (5) implementing an inventory system for supplies and other computer facilities; (6) providing effective instruction as to the proper use of the Club's facilities; (7) implementing controls on computer access; (8) preparing a budget.

As operations manager we are: (1) assessing and changing systems design (where necessary) to simplify use;

(2) providing guidelines on documentation content; (3) requiring comprehensive user documentation; (4) developing and implementing a log system to monitor computer use.

As planner, we identify potential computer applications and set priorities for their review and implementation. The Committee identified 11 potential applications in 1987. We monitored OFNC computer needs and forecasted needed supplies.

We have had a full first year! We want to extend a special thank you to Barbara Martin for contributing her knowledge of OFNC operations and of the Club's membership system before resigning. We expanded to four members by the end of 1987. Our new members are Daniel Filipovic and Nicole Defretière. We welcome Patricia Naraway as the new OFNC computer operator. We also would like to thank the National Museum of Natural Sciences and Dr. Brian Coad for their continued and valued support.

In 1988, we look forward to identifying and assisting in the development of more computer applications for the OFNC members.

S. M. BLAIN

Conservation Committee

L. Maltby (Chairman), S. Blain, M. Boronkay, E. Bottomley, D. Cuddy, P. W. Hall (new Chairman), C. Harris, J. Harrison (Vice-President), F. Levine, B. Martin, J. Reddoch, D. Smith, R. Taylor, E. Todd, J. Topping, Y. Hunt.

The Conservation Committee has been very active nationally, provincially and locally. The size of the committee increased from that of last year. This year around 15–20 members devoted much of their time to conservation.

I have since stepped down as Chairman of the Conservation Committee and am pleased to be able to welcome Peter Hall as the next Chairman.

The following is a list of highlights from the past year:

NATIONAL: (a) *Barry Turner's Excise Tax Proposal*: It was generally agreed that there is a need for more money for wildlife but the Committee expressed some concern as to how such a tax could be implemented. (b) *Environmental Protection Act*: The proposed new "Environmental Protection Act" was reviewed and although it was considered an improvement over existing legislation the Committee felt that it would not provide any further protection for natural areas. However, in spite of its weaknesses the Committee supported the proposed act in principle. (c) *Wildlife '87*: Many events had been scheduled as part of Wildlife '87 and the Conservation Committee participated in National Wildlife Week, Environment Week, etc. A display on Alfred Bog was highlighted in as many different places as possible.

PROVINCIAL: (a) *Alfred Bog*: A draft Management Plan had been prepared for the Steering Committee. The Conservation Committee reviewed and sent comments on the Management Plan to Frank Pope who is chairing the Steering Committee. The Steering Committee has just recently met so some, but slow, progress is being made. (b) *Lanark Crown Management Unit*: The Carleton Place

District of the Ministry of Natural Resources has begun to prepare a timber Management Plan for Crown lands in Lanark County. The Committee is providing input and is watching the progress made in ensuring that our interests are taken into consideration. (c) *Wetlands Policy*: The Committee is constantly involved in commenting and reviewing any documents related to a Wetlands Policy for Ontario; (d) *Marlborough Forest*: The need to identify significant areas to avoid conflicts, i.e., snowmobile trails vs. interpretative areas still exists. The Committee has active representation on the Advisory Committee.

LOCAL: (a) *Regional Municipality of Ottawa-Carleton (RMOC) Waste Plan*: This topic took up a lot of time and many stimulating discussions took place. OFNC had a representative on the RMOC Waste Management Task Force so that our concerns were considered. Recycling began in many parts of the area this year. (b) *Stony Swamp*: Some concern was expressed with regard to a proposed housing subdivision and industrial development that encroached on the southerly boundaries of the conservation area. The Committee supports the protection of Stony Swamp and expressed its concern to the people involved. (c) *Wildlife Garden*: As part of Wildlife '87 celebrations, the Conservation Committee felt that, for its Wildlife '87 project, it could create a wildlife garden. The initial objective was to take a piece of "wasteland" and manage it in such a way as to make it attractive to wildlife. A short list of six sites was evaluated. The top of the list was a site at Carleton University followed by one at the Experimental Farm and one at Britannia. The City and other organizations were approached and all parties reacted very positively to the idea. We are presently trying to line up interested volunteers before we commit the OFNC any further. (d) *Club Brochure*: As part of Wildlife '87 it was also decided that a new Club brochure would be produced. Members of the Conservation Committee, the Education and Publicity Committee and the Membership Committee are working together. (e) *Other Items*: Many other items were discussed which included: (1) Environmental Awareness Strategy for Municipal Representatives; (2) Gypsy Moth and *Bacillus thuringiensis* (Bt) spraying; (3) Conservation Calendar of Events; (4) Autoroute A5; (5) U.S. Embassy location; (6) re-opening of discussions on management and use of Gatineau Park; and (7) Britannia area bridge across Ottawa River. Finally, thanks to all members of the Conservation Committee who volunteered their time to make things happen.

L. S. MALTBY

Education and Publicity Committee

B. Marwood (Chairman), L. Capel, J. Harrison (Vice-President), B. Knight, B. Royds, K. Taylor, D. Thompson, S. Wood, D. Zarski.

The Highlight of the year was the National Capital Commission (NCC) Fall Rhapsody, held from 19 September to 13 October. Bill Knight and Dianna Thompson made this a real success; it was held in the market area, and the Club's workshop on bird feeders gave us valuable exposure. During the period, George McGee, Bill Millar and Dianna Thompson were interviewed on CBC Radio Noon. The NCC French interpreter, Anna

Watelet, was much appreciated. Sixteen other Club members were also involved.

As a result of the 1986 Fall Rhapsody, at NCC's request we presented the workshop on bird feeders at the Stony Swamp Interpretive Centre in February.

Twenty-three Club members took turns at our exhibit at the Ottawa Duck Club Nature Art Show in October. This annual event gives good exposure to the OFNC, and several new members were obtained this year.

Ken Taylor once again successfully organized the Club's role in the Ottawa Regional Science Fair. We awarded prizes as usual. Winners were Raymond Tse, Omar Ames and Piyanjali Tissaratchy.

Using George McGee's bird slide programs, Katherine Mason spoke to Brownies, Cub Scouts and Senior Citizens, and took part in a day-camp program at the Devonshire School.

The Club display, used in several of the above activities, at the National Museum of Natural Sciences' Clubs' Day, and in part at the New Members Night, is under study for revision and updating. A subcommittee, currently D. Thompson and S. Wood, has begun work on this project.

W. K. GUMMER for B. Marwood

Excursions and Lectures Committee

Ross Anderson (Chairman), Robina Bennett, Allan Cameron, Ellaine Dickson, Eileen Evans, Dan Brunton (Vice-President), Colin Gaskell, Christine Henri, Edith Ikeda, Rick Leavens, Philip Martin.

The Excursions and Lectures Committee held bi-monthly meetings in 1987 together with numerous meetings of groups responsible for tours and special projects.

Activities promoted by the Committee for the preparation and enjoyment of all members were as follows: Excursions (34), Day Trips (13), Tours and Overnight trips (2), Lectures and Special Events (21).

In general excursions take place in the Ottawa-Hull area and occupy an evening or half a day. Day trips extend to sites outside our immediate area and are arranged to occupy a full day, morning to night. Tours include overnight stops and extend to such elaborate, extended and well planned events as the Point Pelée trip which occupied four days.

Lectures and special events include a successful series of monthly meetings, the Annual Soirée and Members' Slide Night. Eleven distinguished speakers were guests of The Ottawa Field-Naturalists' Club during the course of the year. The monthly meetings, held at the National Museum of Natural Sciences and open to the general public, include refreshments and were attended by an estimated average of 50 to 80 persons. Largest attendance at a monthly meeting was close to 150 persons for an animated report of the OFNC trip, "Birding Down-Under — Birds, Butterflies and Other Natural Wonders of Queensland and the Northern Territory of Australia".

The Committee welcomes suggestions by interested members of the Club for projects in 1988. Excursion leaders willing to develop and carry out any project of interest to other Club members and to other community groups on behalf of the Club are cordially invited to

contact the chairman or any member of the Committee.

Cordial thanks to members of the Committee who do their own jobs exceedingly well, and to all the volunteers who make excursions and lectures such an important part of Club activities.

R. ANDERSON

Finance Committee

Frank Pope (Chairman), Ron Bedford, Dan Brunton (Vice-President), Bill Cody, Don Davidson, Doug Sample, Frank Valentine, Paul Ward, Ken Young.

The Committee met three times during the year. Major activities included: a review and evaluation of our present insurance coverage; support for the Club's negotiations with the Museum of Natural Sciences regarding our joint liability for the Macoun Field Club; a review, renumbering and definition of the general ledger accounts; a review of the financial aspects of publishing *The Canadian Field-Naturalist*; preparation of guidelines related to special purpose funds; and recommendations for updating certain clauses in the Constitution and By-laws. Also during the year, recommendations were made to the Council on a long term fee structure including specific recommendations for 1988, policies were proposed for two issues: receipts for income tax purposes and retroactive claims for expenses, bank service charges were renegotiated, and an article on life memberships was written for *Trail & Landscape*.

F. POPE

Macoun Field Club Committee

Barry Bendell (Chairman), Martha Camfield, Robin Collins, Stephen Darbyshire, Ellaine Dickson, Paul Hamilton (leader), Jeff Harrison (Vice-President), Rob Lee, Michael Walsh.

In order to stimulate the interest and appreciation of the natural sciences by children, the Macoun Field Club continued to provide an active and varied program of speakers and field trips in 1987. There were 16 field trips during the year. These included trips to Luskville Falls, Pakenham, and Bishop's Mills. Field trips went regularly to the Macoun Field Club study area at Stony Swamp, where members have been encouraged to develop ongoing studies. Meetings have focussed on the themes of arctic ecology, marine environments, the tropics, and the collection, preservation and identification of biological specimens. Outside speakers regularly gave talks on related subjects, especially to the senior group (grades 9-13). This year, the club produced Volume 41 of the club journal, *The Little Bear*. A monthly newsletter continues to be produced, now under the editorship of a member of the senior group, Carina Cojen.

The major goal of this committee during 1987 was to increase membership and participation in the club. To meet this objective, the club was promoted through written articles in *Trail and Landscape*, and the *Biome*, and during a CBC radio interview. The club also presented posters during National Wildlife Week and Club's Day at the National Museum of Natural Sciences. The result has been an increased interest in the club. The active membership, as of November 1987, was 50, as compared to 34 the previous

year. The junior group (grades 4–6), with 25, is at full membership. The intermediate group (grades 7–8) has 11 active members, and the senior group has 14. The committee was also encouraged by increased participation and enthusiasm of the members.

Over nearly 40 years, the Macoun Field Club has had many dedicated leaders who have put a great deal of personal time and effort into the club. As a token of appreciation of this kind of dedication, the committee recommended that an honorarium be established for the current and future leaders. Such an honorarium has been established by council.

During the 1987–88 school year, the club will continue under the able leadership of Paul Hamilton. Many thanks are due Rob Lee for his assistance and leadership, as well as Martha Camfield. We also wish to thank all those who gave talks to the club, and those who led or assisted in club outings.

B. BENDELL

Membership Committee

Eileen Evans (Chairman), Eleanor Bottomley, Dan Brunton (Vice-President), Barbara Campbell, Elaine Dickson, Fran Goodspeed, Barbara Hurt, Aileen Mason, Bette Stern, Ken Strang.

Club membership increased slightly in 1987. Local membership increased by 26 and non-local membership decreased by 9. The number of new members joining the Club in 1987 was 133, an increase of 4 from the 129 who joined in 1986. The total membership of the Club as of December 1, 1987 was 1177 — an increase of 17 from the 1986 total of 1160. Sustaining members totalled 42 — a decrease of 10 from last year. There was 1 new life member. Family membership totalled 327 — no change from last year. Based on an average of two members per family, we estimate the total membership served by the Club to be 1504.

The following chart is a summary of membership distribution. Figures in brackets are 1986 totals.

Thirty-four new names were added to the volunteer list. These lists, which are circulated to the various committees, provide a valuable source of help to the Club and the Committee would like to thank all those who have offered their help.

The Membership Committee again co-hosted a successful New Members Night on November 13th. Approximately 75 people attended, including 4 honorary

members and 15 Council members. Wine, cheese, cakes and punch were served in the Salon of the National Museum of Natural Sciences. At the end of the evening \$16.00 was raised by an auction of leftover cheese. This amount has been donated to the Alfred Bog Fund. Many thanks are due to all those who worked to make this event such a success.

This year the Committee reactivated the practice of awarding Club pins to members of 50 years standing. Letters of recognition and pins were sent to I. L. Conners, O. E. Devitt, C. H. Kindle, J. E. V. Goodwill, W. H. Minshall and Mrs. V. McGiffin. Letters alone were sent to W. E. Godfrey, L. S. Russell and W. Dore as these members already have pins.

The Committee would like to extend special thanks to Barbara Martin for her every willing and efficient operation of the computer. The Chairman would like to thank all the members of the Committee for their help during the year and particularly Elaine Dickson for the use of her home and her expertise.

E. EVANS

Publications Committee

The Publications Committee met three times in 1987, with its chief function to oversee, and advise Council on, the Club's publications.

Three issues of *The Canadian Field-Naturalist* were published in 1987: Volume 100, issue 4, and Volume 101, issues 1 and 2. The last of these with 200 pages is the largest single issue in the history of the journal. The three issues included, in 486 pages, 30 articles, 25 notes, 43 book reviews, 19(+1) COSEWIC reports on endangered species, 332 new titles, 1 commemorative tribute and 10 pages of news and comments. Although, due to the editor's professional duties, the publication schedule is running late, the journal is running in good health. The panel of Associate Editors remains unchanged.

Volume 21 of *Trail & Landscape* was published in 5 issues and 280 pages. Among the highlights were Brian Coad's "Checklist of Fishes of the Ottawa District" and several articles by Joyce and Allan Reddoch on Ottawa District orchids. Again this year a high percentage of paging (39%) related to birds. Also in 1987 an Index to the first 20 volumes of *Trail & Landscape* under the authorship of Bill Gummer was produced. Several changes relating to *Trail & Landscape* were approved beginning with Volume 22. Publication will change to 4

1987 Membership in The Ottawa Field-Naturalists' Club

Type	Canada		Foreign		Total
	Local	Other	U.S.A.	Other	
Individual	454 (420)	232 (243)	52 (53)	7 (6)	745 (722)
Family	302 (301)	24 (24)	1 (2)	0 (0)	327 (327)
Sustaining	37 (48)	5 (4)	0 (0)	0 (0)	42 (52)
Life	16 (15)	18 (18)	3 (3)	2 (2)	39 (38)
Honorary	16 (15)	7 (5)	1 (1)	0 (0)	24 (21)
	825 (799)	286 (294)	57 (59)	9 (8)	1177 (1160)

issues from 5, a new cover design will appear, and total paging will likely be smaller.

The final issue of *The Shrike*, of which publication was suspended in 1986, was published. It reported on bird sightings during the period August 1985 to February 1986.

A book relating to the natural history of the Ottawa District written by Dan Brunton and co-published by the OFNC will be published soon by the Ottawa Citizen.

The Publications Committee thanks the editorial and production staffs of *The Canadian Field-Naturalist* and *Trail & Landscape* for their continued service to the OFNC, and thanks all others contributing to support of publications, notably the referees and indexers.

R. E. BEDFORD

The following comments were made after the report was read.

(a) *Awards Committee*

Dan Brunton added that nominations can still be accepted for this year's awards.

(b) *Birds Committee*

Dan Brunton wanted to clarify that of 21 reports submitted to the Bird Records Subcommittee, 14 were accepted as valid reports. The balance are open to question in some way but all reports are kept.

Bill Gummer asked why the recommendation was made to "stop activity in '87" re. compiling data sheets that previously were published in *The Shrike*. Wright Smith clarified this point by explaining that there was only one regular contributor.

(c) *Conservation Committee*

Bill Gummer noted that the Club wrote to two Ministries of the Ontario government regarding Stony Swamp and received no response to date.

There was a call for volunteers to help with the Wildlife Garden project.

An inquiry was made as to why the OFNC was involved with the U.S. Embassy location and has the Club taken a stand on this issue? Bill Gummer explained that Barbara Martin represented the Club at a Committee which assessed the pro's and con's of the various sites proposed for the new Embassy. She assessed the areas and none were significant environmentally. This information was passed on to the National Capital Commission (NCC).

Membership Committee should be included as part of the team working on the Club brochure.

It was noted that a consultant was hired by NCC to study the traffic patterns around Britannia to determine the need for a bridge. A meeting will be held the following weekend and the Club will be participating.

(d) *Education and Publicity*

A member asked whether the Club has a school program. Ellaine Dickson answered that although we get requests from schools we have no formal curriculum involvement and participate only when requested. The question was asked as to whether School Boards have been approached on this topic. It was noted that NMNS has a volunteer program for schools and that the OFNC works with young people through the Macoun Field Club. Roger Taylor reminded the Club that the Canadian Nature Federation and World Wildlife Fund offer resource material called Operation Lifeline for teachers. He suggested that the OFNC take on the project of getting this material into the schools.

(e) *Finance Committee*

The chairman of this committee set a good example for report length. Those short sentences say that this Committee has done the best financial review of the Club that has been done in a long time. Bill Gummer thanked the members of Finance Committee.

It was noted that with regards to the 40 year old Macoun Field Club, the OFNC and NMNS have recently reconfirmed their relationship with this junior club.

(f) *Macoun Club Committee*

Bill Gummer noted that this was one of the committees that met its goals. The Museum published an article about the MFC in its publication the *Biome*.

(g) *Membership Committee*

Barbara Campbell noted that for the first time in four years, membership has increased.

(h) *Publications Committee*

Dan Brunton commented that the natural history book he is preparing is being co-published by the OFNC. Roger Taylor asked what the publication date would be. The book may be ready in four to six weeks.

One of the goals of Publications Committee should be to revise its Publication Policy because of the loss of *The Shrike* and the changes to *Trail & Landscape*.

A few general comments were made:

(1) It was recommended that full names be used when listing Committee members.

(2) A table of contents for the report to the Annual Business Meeting would be handy.

Peter Hall moved (2nd Harry Thomson) to accept the Report of Council with amendments as suggested at the meeting.

(Motion Carried)

6. Nominations

Membership on the 1987 Nominations Committee was Barbara Campbell (Chairman), Ellaine Dickson and Roger Taylor.

Barbara Campbell announced the 1987 Council members who are retiring: Ross Anderson, Allan Cameron, Mona Coleman, Fern Levine, Lynda Maltby, Joyce Reddoch, and Roger Taylor.

The proposed slate for the 1988 Council was presented:

The Executive: President: Bill Gummer; Vice-President: Jeff Harrison; Vice-President: Ken Strang; Treasurer: Frank Valentine; Recording Secretary: Roy John; and Corresponding Secretary: Barbara Campbell.

Other Members of the Council: Barry Bendell, Ron Bedford, Dan Brunton, Bill Cody, *Kathleen Conlan, Francis Cook, *Peter Croal, *Barb Desrochers, Ellaine Dickson, *Doreen Duchesne, Eileen Evans, Peter Hall, *Shane Jordan, *Catherine O'Keefe, Frank Pope, Wright Smith, Paul Ward.

Barbara Campbell moved (2nd Roger Taylor) that the slate of nominations be approved.

(Motion Carried)

7. New Business

(a) A review will be made of what has been submitted by Birds Committee to the National Archives.

(b) Bill Gummer re-iterated the need for a Club office. The Ottawa Field-Naturalists' Club owns a lot of equipment and has files and items scattered all over and the need for our own place is becoming even more pressing. If anyone has any ideas on this subject, please come forward!

(c) Bill Gummer thanked Teresa Fuller for her typing assistance and Christine Henri for providing refreshments over the past year.

(d) Recently the Canadian Nature Federation was allowed to use our mailing list on a one time basis to issue their new catalogue to OFNC members. A portion of the purchases made by Club members was donated to the Alfred Bog Fund. This amounted to nearly \$100 for the Fund. Thank you members and CNF!

(e) Roger Taylor announced that the Canadian Nature Federation in cooperation with the Canadian Wildlife Service is setting up a Bird Watchers Badge Programme. The idea originated with the CWS. Theresa Aniskowicz who is Conservation Director at CNF is exploring possibilities with the Macoun Field Club to set up a pilot study. This idea could spread nationally.

(f) The Actica exhibit which is displayed at National Museum of Natural Sciences has a large Ottawa Field-Naturalists' Club component.

8. Adjournement

Ellaine Dickson moved (2nd Aileen Mason) that the meeting be adjourned. Time 2132 hrs.

(Motion Carried)

9. Following the business meeting, the group met for coffee and dessert and then broke into four discussion groups to discuss various aspects of the Club's activities: Awards, Education & Publicity, Macoun; Birds, Excursions & Lectures; Conservation; and Finance, Membership, Publications.

BARBARA CAMPBELL
Recording Secretary

*New member of Council

Book Reviews

ZOOLOGY

Seabirds of the World — A Photographic Guide

By Peter Harrison. 1987. Christopher Helm Ltd, London. 317 pp., illus., £ 16.

Peter Harrison has produced a companion volume to his *Seabirds: An Identification Guide*. This new book is illustrated almost entirely by photographs and is smaller and more portable. He has also reduced the number of species covered to 320.

I prefer paintings to photographs as illustrations for field guides. An artist can orient the bird so that the key characteristics can be seen to maximum advantage. Photographs can be confusing, but they can also be realistic. My copy arrived just before I went on three pelagics during which Leach's, Wilson's, and Band-rumped Storm-petrels were all possible. I had used Harrison's original book, plus several articles to inform myself on the identification keys. Looking at the sets of photos for these birds in this new book, I was brought back to reality. The field guide differences are there, but the immediate impression is still one of very similar species. When the birds are moving and the boat is moving also, then the difficulties increase. I have already seen several hundred petrels this year and flight pattern, which no photograph or painting can supply, is still the most useful key.

Harrison has tried to put two flight pictures; one showing the dorsal view, the other the ventral, for all the species. Most of the photographs are excellent. In some cases, particularly for the rarer species, he has used poorer quality material,

generally being out of focus. (I have yet to see an excellent photograph of an Audubon's Shearwater). For a few birds, apparently no photographs exist and these are replaced by paintings. The pictures are set six to a page so are fairly small (6 cm × 5 cm). In a few of the pictures the birds, but not the background, have a curious yellow hue. The general quality is however good. After the photos Harrison includes a short field guide style description of each species with a small (4 cm × 3 cm) range map. This includes a brief identification note, some comments on habits and distribution, and a list of the potentially confusing species. This is followed by a tubenose identification section, illustrated with Harrison's own first-rate, black-and-white drawings. Incidentally, this is the first book I have seen which includes the newly-described, Amsterdam Albatross (*Diomedea amsterdamensis*).

Those who do not own Harrison's original book *Seabirds: An Identification Guide* should buy it first. It is a classic and will be a standard reference for years to come. This new volume is a companion to the first, giving a better sense of reality. It is more convenient to carry and will be the one I take into the field. A well organized and produced book, it will make an excellent present, as long as birders can resist buying it for themselves.

ROY JOHN

8 Aurora Crescent, Nepean, Ontario K2G 0Z7

Diving Birds of North America

By Paul A. Johnsgard. 1987. University of Nebraska Press, Lincoln. 292 pp., illus. U.S.\$45.

The first page I looked at in this book was a map showing the breeding range of the Horned Puffin. To confirm the printed title, the page also included a neat line drawing of a Horned Puffin. Unfortunately, all the breeding colonies were

located on the east coast. Clearly the map shows the breeding locations of the Atlantic Puffin. Similarly, the Atlantic Puffin map shows the Horned Puffin locations in the Pacific. Mistreatment of these species does not end here. The inferred weight (Table 7) for Horned Puffin is 60g and for Atlantic Puffin is 1000g (both birds are around 500g).

These are not the only problems to mar an otherwise useful book. Some items are simply wrong. The author places Boneventure Island in New Brunswick, for example. Some are questionable. There are various places where the percentages do not add up to 100. It is not clear whether something is missing, the mathematics is incorrect, or I am misinterpreting the data. And some things are poorly done. Map symbols are inconsistent and are not well explained. Indeed on the map for the (Horned) Atlantic Puffin (p. 259), Newfoundland is moved about 600 km north and 300 km east without any explanation.

I suggest the author change the title to "Loons, Grebes, and Auks of North America". This would be more accurate as other surface diving birds (Cormorants, Anhinga, and ducks) and plunge divers (Gannets, boobies, terns, and pelicans) are not included.

To assemble the book, the author has reviewed over 500 references, mostly from scientific literature. It is difficult to estimate how complete this list is, but there are certainly some appropriate publications missing. This may explain why colonies such as Witless Bay and Cape St. Mary's are not mentioned.

What Paul Johnsguard has done, in fact, is to cull literature and compile the information into an overall summary. It does not appear that the author has contributed any original research himself but this is not important. The writing style is logical and clear, but the author assumes an elementary knowledge of avian biology. He tends to use the more precise and correct scientific terms (for example, gadids for the cod family). However, this need not deter the non-scientist reader as it is usually obvious from the text what is meant.

The book is divided into two parts. The first deals with the comparative biology and covers evolution, structure, behaviour, feeding, and breeding. This section makes interesting reading and, for me, answered a number of questions. It is difficult to understand, though, why the author omitted cormorants. For those birds covered, he

has analysed the data to show how the characteristics of each species enable it to survive in its chosen environment. For example, wing shapes relative to migratory behaviour or bill size and shape compared to prey characteristics are carefully and meaningfully discussed.

The second part of the book is devoted to the species accounts. Four species of loon, six species of grebe, and seventeen species of alcid are covered in considerable detail. Neither the Western and Clark's Grebe nor the Pacific and Arctic Loons had been split when the book went to press. The author treats them as a subspecies in sufficient depth that the reader will readily be able to separate them as species.

Each species account includes a description, discussion on ecology, general biology, social behaviour, breeding population, and distribution. Each account is accompanied by a distribution map, which for most species occupies a full page. I found this portion of the book easy to read, with a nice balance between detail and length.

The author has made excellent use of the drawings. No credit is given for the artist so I assume they were done by Johnsguard himself. They are not the most artistic drawings I have seen, but they are competently done and cleverly arranged to show behaviour or physical characteristics. There are 32 coloured plates, mostly photographs of varying quality. Those by Kenneth Fink and Gary Nuechterlein are excellent. Two very good paintings by M. Marcusou are also included.

Despite the negative comments there is much in this book to make it a worthwhile purchase. It parcels a lot of good information into a well organized reference. It is saddening that the irritating errors have devalued an otherwise useful book. A change of title and a rigorous editing should improve it immeasurably.

ROY JOHN

8 Aurora Crescent, Nepean, Ontario K2G 0Z7

A Guide to Animal Tracking and Behavior

By D. W. Stokes and L. Q. Stokes. 1986. Little, Brown and Company, Boston. 418 pp., illus. U.S.\$18.95.

Animal Signatures

By E. Claridge and E. A. Milligan. 1984. Nova Scotia Museum, Department of Education. 54 pp., illus. \$2.95.

These two publications are vastly different in scale, although both deal with the subject of teaching the identification of animal signs. *Animal Signatures* is a short, paper, and staple-bound booklet, while *A Guide to Animal Tracking and Behavior* is one of the Stokes Nature Guides series in hard cover and glossy paper. The former booklet

is at best rudimentary, and probably aimed at primary school children. The latter contains considerably more information and appears to be written for the high school level naturalist.

Animal Signatures shows the tracks of 20 or so of the common wild and domesticated species which might be seen in Nova Scotia, and has a short description of size, colour and habitat of each species. There are also a few drawings of scats, and browsed twigs to help the young naturalist in the identification of sign.

The Stokes Guide is obviously a much more ambitious work, albeit still at a very general level. This book is not for an experienced naturalist, but would be useful for a young person interested in natural history of common mammalian species of central latitudes of North America. There are basically two sections to the book; the first deals with tracks, scats, and other sign, while the second presents a general description of movement, breeding, and feeding behaviours of each species. Most common land mammals of Canada are included except for Marten (*Martes americana*), Lynx (*Felis lynx*), Cougars (*F. concolor*), Caribou (*Rangifer tarandus*), Mule Deer (*Odocoileus hemionus*), as well as several small mammal

species. The section on track descriptions is generally well done except for the mustelids, which are shown with foot impressions apart instead of overlapping at the edges. Further, the omission of Marten detracts from possible distinction among tracks of these species. Scats and other signs (scratchings, piles of seeds, dens, browsed twigs, scrapes) are all well-illustrated and will help in determining which species are present in an area. Tracks are described by size, and pattern in various gaits. I was impressed by the dual organization by species and groups with similar looking tracks in order to help distinguish among species. The descriptions of behaviours are factually correct, although somewhat over-generalized. For example, it is stated that Moose (*Alces alces*) associate in groups for much of the winter which is clearly false except in montane areas, parts of Alaska, or when forced to do so by exceptionally deep snow.

The Stokes Guide is a very attractive book and is informative and easy to read. I can recommend it for aspiring young naturalists.

IAN D. THOMPSON

Canadian Forestry Service, Box 6028, St. John's, Newfoundland A1C 5X8

Animal Intelligence: Insights into the Animal Mind

Edited by R. J. Hoage and L. Goldman. 1986. Smithsonian Institution Press, Washington. 207 pp., illus. U.S. \$10.95.

Perhaps any book, especially a multiply authored one, on this controversial topic is bound to be an aggravatingly uneven and unsatisfying potpourri. Certainly this one is. Based on a public symposium held at the National Zoological Park, it contains contributions ranging from research reports through philosophical speculations to historical surveys. As an elementary introduction to the issues the work is patchy. Neither does it rise to the hard task of tackling the thorny problems which require examination in this fascinating area. There is no index or concluding statement by the editors, the chapters suffer from some inevitable overlap, and some of the references are not just old but outdated.

What might be expected of such a volume? A coherent presentation would involve a delineation of basic terms, assumptions, and experimental techniques, a review of relevant data and accompanying interpretations, and a consideration of the impact of these findings for both

academic topics in complex and flexible behaviour and applied problems such as animal welfare, as well as suggestions for further research. Such a presentation is not to be found here, although there is some excellent material contained in these pages. Chief among this is the contribution by Colin Beer who, here as elsewhere, provides a magisterial synthesis of scientific rigour with philosophical erudition by investigating the various meanings of "intelligence" and its functional role. Three other chapters provide experimental results which illuminate aspects of animal intelligence. Geoff Galef presents a critical overview of traditions and social learning, including his own findings. James and Carol Gould supply a valuable perspective based on research with invertebrates. The complex behaviour of insects can be well adapted and yet very rigid. Intriguing work, in which honey bees refuse to search for food when dancing hive mates are tricked into indicating a location in the middle of a lake, reveal the extent to which this complexity can evolve. Ben Beck shows that the correlation between tool use and intelligence is far from perfect, and usefully draws attention to the need to

re-assess the use of key terms by comparing termite hunting by chimpanzees and assassin bugs.

Other chapters fail to contribute to the theme and some would scarcely pass as undergraduate essays. There is scant attention to such matters as human intelligence or the roles of anatomical, physiological, or ecological constraints on adaptive behaviour. The ghost of the *Scala Naturae* (the pre-Darwinian notion that animals, rather than being the twigs on an evolutionary tree, can be arranged on a single dimension of proximity to humans) does not appear to have been fully exorcised. Contrary to several of the authors, correlations between gross measures of neuroanatomy and behaviour are not very illuminating, anthropomorphism and anecdotes are an insufficient basis for scientific conclusions, and comparisons among species or arbitrary laboratory tasks are fundamentally misconceived. Calls

for the study of "mental images" are made apparently in ignorance of the crisis through which psychology struggled a century ago, impaled on this metaphysical fantasy. Predictions which are presented as the outcome of an "intentional analysis" of animal behaviour are more parsimoniously generated by considering natural selection or individual conditioning. Overall, this book is one of numerous publications based on the current but ephemeral bandwagon of animal cognition. When the shouting has abated, hard data and careful scrutiny (or, in Galef's felicitous phrase, "a healthy skepticism and a commitment to empiricism") will achieve the investigation of animal intelligence.

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An Introduction to Behavioural Ecology

Edited by J. R. Krebs and N. B. Davies. 1987. Sinauer, Sunderland, Massachusetts. ix + 389 pp., illus. U.S.\$18.95.

For the past couple of decades a ferment of research has bubbled at the interface of ecology, ethology, and evolutionary biology. The first edition of this work, six years ago, provided a comprehensive review of this activity.

The present edition has the virtues of its well-received predecessor. After introducing the material to be covered and the style of informal shorthand to be used, the authors take three chapters to establish the theoretical basis of the discipline in terms of natural selection, the methods for testing hypotheses, and the view of behavioural activities as means for maximizing fitness. The issue of levels of selection is examined, as are the roles of experiments and comparisons between individuals and species in drawing conclusions. Appropriate attention is paid to the central problem of discovering the correct currency in which to measure activities. The next four chapters consider evolutionary arms races between predators and prey, competition for resources, group living, and aggressive behaviour. Cases include mimicry and warning colouration, brood parasitism, economic defendability of resources, the role of food and predators on group size, and types of animal conflicts.

Aspects of reproduction, including sexual conflict and selection, parental care, and mating

systems are examined in the ensuing three chapters. There is good discussion of such topics as the inherent asymmetry between male and female, sex ratio in different animal groups, and comparative mating strategies including leks, reversal of sexual roles, and polyandry. Ecological factors are presented as influencing the distribution of females and consequent social systems. In many species alternative strategies for reproduction are found, such as hermaphroditism or behavioural polymorphisms involving cuckoldry. Over the next three chapters, the authors outline the evolution of altruism and cooperation in vertebrates and social insects (for which the treatment is especially detailed). The genetic basis of kin selection, conflicts between breeding and non-breeding individuals, and the occurrence of helping behaviour and reciprocity in social groups are all considered. The ecology and evolution of communicative signals is reviewed in the penultimate chapter with attention to environmental constraints, selection of signals for various functions, and variation between and within individuals. There is a useful final discussion of the validity of premises involving selection and optimality, and explanations of function and causation.

The book contains a lucid exposition of the subject material with each chapter concluding with a summary and suggestions for discussion and further reading. It is well referenced and indexed

and appropriately illustrated with tables, figures, and boxes for selected topics. The authors hew closely to their functional theme, with little attention to historical details or proximate mechanisms. There is laudable attention paid to issues of methodology and interpretation. The importance of game theory to many problems is evident throughout the volume, and the authors choose carefully, from among the multitude of studies which bandy about such terms as "strategy", those which actually carry out a strategic analysis. These examples, while unavoidably reflecting the majority of studies on birds and mammals, are also well drawn to represent a phylogenetic diversity. Critics of the adaptationist approach which motivates the entire text will no doubt continue to fret over the mediocre

agreement between observations and predictions in some of the cases cited, and to decry the lack of emphasis on outstanding criticisms to the overall approach. The layout of the book is very similar to that of the first edition, but a third larger. Indeed, the similarity is so striking that the absence of a justification by the authors for this new edition raises concern about the need for it, especially given the appearance three years ago of the second edition of their edited volume on the same subject. Nonetheless, for those interested in behavioural ecology who missed these earlier works, this book is a superb presentation.

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The Encyclopedia of Animal Behavior

Edited by P. J. B. Slater. 1987. Facts on File, New York.
xvi + 144 pp., illus. U.S.\$24.95.

The series of encyclopedias of which Slater's is the most recent number are not fat and hefty texts. Rather they are slim, large-format volumes, richly illustrated so that over a half of the space is pictorial. After an introduction outlining the study of animal behaviour and its history and applications, the contributions of the 25 authors are grouped into four sections. Under the behaviour of individuals are considered feeding and defences, animal architecture, behavioural rhythms, and orientation and migration. The second section on animal relationships includes communication, courtship, parental behaviour, and breeding systems. An especially well done and valuable section on the origins of behaviour examines learning, problems of the nature and nurture of behaviour, and evolution and sociobiology. These important and controversial topics are admirably given suitable attention. The final section on social organization also provides a good survey of insects and vertebrates, interspe-

cific associations, and animal culture (although it is surprising to see the famous but unproven case of British birds opening milk bottles still cited). Bibliography, glossary, and index (in tiny print) are appended.

The writing style is pleasingly even, lucid, and informative. The examples employed are drawn from both sides of the Atlantic Ocean and elsewhere, and this breadth provides a welcome panorama for the discipline. On a comparative basis, the two most similar works to the present book are the 1977 *Grzimek's Encyclopedia of Ethology* and the 1982 *Oxford Companion to Animal Behavior*. Both are more substantial but less profusely illustrated, and written at a higher level. Slater's volume serves as an attractive introduction to animal behaviour for the uninitiated seeking a reliable overview.

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Butterflies and Moths

By Barbara Batulla. 1986. Canadian Album Series.
Hyperion Press, Winnipeg. 40 pp., illus. \$4.95.

In recent years, there has been an encouraging increase in the publication of children's books with

natural history themes. Furthermore, many of them are being written by Canadian authors, for Canadian children, with Canadian content. Barbara Batulla's *Butterflies and Moths* is such a

book, and aims to catch and hold the interest of young future naturalists — no mean challenge this.

The book is certainly attractive at first glance. Colourful paintings on the front and back covers illustrate the species of butterflies and moths described within. The information is presented in three sections for each species: first a fictionalized "nature story", then a species description, and finally, a full-page colouring book illustration of one or more stages in the life cycle of the butterfly or moth.

It seems reasonable to critique this book by looking at each of these sections separately.

In the first section, the author has selected a concept to present to readers, then chosen a species to illustrate that point. She weaves the information into a "nature story", sometimes featuring children as central characters, otherwise writing the story from the viewpoint of the insect. The stories contain fascinating and technical information on subjects ranging from mutualism and mimicry to mating behaviours and migration. Unfortunately, they are often weakly contrived and somewhat patronizing. Take for example, the story of two girls driving to the beach through a Painted Lady migration. It is used as a vehicle to discuss migration behaviours of this butterfly, but has very little coherence or depth as a story. Therefore in my opinion, it will not appeal to the age group presented, namely children in their teens, neither will it interest very young children who will not relate to the central characters.

It should be noted, however, that the stories are much more effective in those examples where the insects themselves are the central characters. Children will in fact, be intrigued by the adventures of such insects as the Viceroy Butterfly and the Cecropia Moth.

A strong point of *Butterflies and Moths* is the more direct style of presentation which the author has chosen to use in the Life Cycles sections. My viewpoint is that these descriptions and life cycle summaries will have more appeal to youngsters by far, than the nature stories. Included is information

about the relatedness of species, larval host plants, metamorphosis, and distribution patterns. Unfortunately, some of the information is misleading, as for instance the statement that Tiger Swallowtails occur in Eastern and Central North America. Implied is that none occur in the west; of course there are also several species in Western Canada.

As might be expected in a book appearing under the heading Canadian Album Series, the information in general pertains to Canada. However, one must wonder why two species were included which do not occur in this country at all.

In regards to the illustrations, the artistic quality in general leaves much to be desired. Colouring instructions are very vague, and youngsters would do well to refer instead to the paintings on the book cover.

Perhaps the most glaring weakness then, of *Butterflies and Moths*, is that the author has failed to identify a target audience. Accordingly, the "stories" in the main are too difficult for very young children to read, while on the other hand, children who are able to read them may find them superficial. An eleven-year old friend of mine has this to say, "The stories are a little bit childish for a person my age, although the information following them is almost too difficult to understand without adult help . . . I usually don't read books like this for the colouring, but for the information, so I would rather have the pictures coloured in."

In summary, this book is neither a colouring book nor a nature story book, primarily because it attempts to be both. It contains, however, a great deal of information that is sure to fascinate, and for this reason author entomologist Barbara Batulla will no doubt have succeeded in sparking interest in Lepidoptera for some children. Consequently, parents, children's librarians, and children in the age range of five to twelve will be interested in *Butterflies and Moths*.

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Eider Ducks in Canada

Edited by Austin Reed. Canadian Wildlife Service Report Series No. 47. Canadian Government Publishing Centre, Ottawa. 177 pp., illus. \$19.50 in Canada; \$23.40 elsewhere.

Good news! Canadian eider duck populations, with some exceptions, are stable and have

increased substantially since the signing of the Migratory Birds Convention Act in 1916. Before the Act was implemented, harvesting of the sea ducks and their eggs had reduced populations alarmingly. It is a pleasant change to read about a conservation success. The total North American

population is currently estimated at about two million.

This book discusses King and Common Eider duck distribution and abundance, subspecies, winter distribution, ecology, and commercial down harvesting. It comprises 18 papers, five of them in French, written by contributors from the Canadian Wildlife Service, The Makivik Corporation (the corporate body of the Northern Quebec Inuit Association), Fisheries and Oceans Canada, and Canadian universities. Interesting and relevant inclusions are abstracts of papers given in Inuktitut. Another paper summarizes interviews with Inuit hunters in Northern Quebec.

Eider duck protection is another example of the dilemma facing conservationists everywhere: compromises are required to satisfy both the necessity for indigenous people having a subsistence economy to harvest wildlife, and the need to conserve wildlife. A case cited is of the total disappearance of eiders within 150 km of Cape Dorset following settlement there.

Nine papers discuss the population surveys of the last 30 years. A paper by H. L. Mendall describes a new method of identification of the five subspecies of Common Eider using beak conformation and measurement instead of wings.

T. W. Barry's paper deals with the poorly researched King and Common Eider populations of the Western Arctic, which are entirely separate from the Eastern eiders (allopatric). King Eider numbers are difficult to estimate because they do not nest colonially and identification is unreliable except by ground survey. Nests are widely dispersed on or near isolated ponds inland from the coast.

Almost all the authors plead for further research to provide basic knowledge of populations and their movements, but the distance of nesting areas from inhabited areas aggravates the costs, difficulties, and dangers of arctic research. Nevertheless "responsible management of wildlife populations can only be accomplished when decisions stem from solid data on basic population parameters" (Abraham and Finney). If the Northwest Passage becomes an oil tanker route, or if an oil rig is damaged, the resulting

oil spill could be disastrous for all the wildlife using arctic waters. Furthermore, as settlement and development grow in the north, good data are needed to help limit damage to wildlife. Similar pollution dangers exist for the nesting populations of the St. Lawrence Gulf and estuary. In Newfoundland, the proximity of the proposed oil development could affect overwintering birds on the east coast; there the sea ducks already suffer heavy losses during the legal hunting season which extends from September to 10 March. An estimated 23 000 were shot in 1983.

The paper by Austin Reed describes commercial eider down harvesting in Canada. It is a small industry with a yearly production of about 250 kg of clean down, with a market price of about \$450/kg. Females readily abandon their nests if they are disturbed too often; with a low fledging rate of only 8% of eggs laid, down harvesting therefore poses a conservation problem. In Iceland eiders have become tolerant of disturbance, so that farmers can harvest the down at appropriate times, but the less accessible island colonies in Canada can usually be visited only once during the season.

The final paper by A. Reed and A. J. Erskine gives an excellent summary of the "state of the species". The authors strongly recommend increased legal protection to the eider populations of Newfoundland and the Lower North Shore of the St. Lawrence. Tribute is paid to the determined effort and success of the RCMP and CWS to enforce existing laws, and to the Quebec-Labrador Foundation programme to educate the inhabitants of the Lower North Shore to limit shooting and eggging of all species of birds in that area.

This book provides valuable baseline data and information on migration routes and populations for species which are relatively poorly understood. For birdwatchers, the maps throughout the book would be useful since they clearly show migration routes, overwintering sites, and nesting areas.

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The Biology of Australasian Frogs and Reptiles

Edited by G. Grigg, R. Shine, and H. Elmann. 1985. Proceedings of the Australasian Herpetological Conference, Sydney, August, 1984. Surrey Beatty and Sons, Chipping Norton, Australia. xvi + 527 pp., illus. + plates. Aust. \$56.00 (U.S. \$59.00, includes postage).

More than 150 people convened at the Australasian Herpetological Conference held in Sydney in 1984, many of them contributing to one or more of the eight organized symposia and two contributed paper sessions. The end result has been

a magnificent, medium-sized volume summarizing the state of research in the Australasian realm. Organized into seven major sections, the volume consists of 63 indexed contributed papers in standard journal format; each contribution has its own references and separately numbered figures; some have exquisite coloured plates.

The volume itself is divided into seven major sections including, in order of presentation, Population Ecology (with 11 papers), Ecological Biogeography (6), Phylogeny of Elapid Snakes (12), Reproductive Biology (12), Physiological Ecology (8), Rare and Endangered Species (9), and as associated titles, Husbandry (4) and Snakebite (1). As expected from a general review of active research programs centering in Australasia, there is little cohesiveness among the various contributions. The contributions of each section are organized by taxa with all frog studies being presented first, and crocodilian investigations last. The diversity of taxa surveyed under each major group varies from approximately equal representation among frogs, lizards, snakes, turtles, and crocodiles to, for example, a strong bias of four of the eight topics of Physiological Ecology focusing on crocodiles. Three of the Ecological Biogeography papers deal more with paleobiogeography. The title of the volume may be considered to be somewhat misleading because only two papers consider herpetofaunal elements outside of Australia and New Zealand. Considering the diversity of topics, except for elapid snake phylogeny, many ardent researchers may find only one or a few papers to be of primary interest. However, there is much to be learned from most writings. The editors have done an admirable job of reviewing and thus ensuring high quality papers that are clear and concise.

Although the topics are generally scattered, there is much to be admired about this volume. Field naturalists will find discussions of habitat use, activity patterns, population density estimates, and season shifts to be of significant comparative value and interest. To a great extent, the investigations are up to date and lucidly

explained making it easy to duplicate or expand upon methods. Numerous new ideas for field investigations are stimulated by the various discussions — ideas which could be carried out as easily in North America as in Australia, although the test animals would necessarily have to be different. In terms of ecological data, this volume is data rich. Quite apart from the value of this contribution to naturalists in general, herpetologists will be delighted, especially those keen to learn about the phylogenetic relationships of Australian and other elapid snakes. Multiple approaches are used to investigate the genealogy of the species-rich elapid snake fauna of Australia. Indeed, the numerous suggestions for taxonomic and phylogenetic rearrangements of the snakes necessitate that all serious snake systematists have the book readily at hand. For these reasons, *The Biology of Australasian Frogs and Reptiles* should prove to be of great value, if not essential, to virtually all herpetologists and to many broad-based biologists and naturalists as well.

In comparison, this attractively-packaged volume represents a large expansion of earlier symposia volumes including, *Proceedings of the Melbourne Herpetological Symposium* edited by Banks and Martin (1981) and *New Zealand Herpetology* edited by Newman (1982). However, because the format of the book is that of a technical journal, less advanced students may find some of the material difficult to comprehend. Faunistic works, such as Cogger's (1983) outstanding *Reptiles and Amphibians of Australia*, are still indispensable. Dollar for dollar, the hard-bound book is a good buy considering the quantity and quality of the contributed papers, and the high standards of publication. The editors are to be congratulated for their excellent work and for setting high standards for future volumes.

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Handbook of Canadian Mammals, 2: Bats

By C. G. van Zyll de Jong. 1985. National Museums of Canada, Ottawa. 212 pp., illus. \$19.95. (also available in a French edition).

This is an excellent book. It begins by introducing bats and covering topics from anatomy to public

health, and classification to olfaction, setting the stage for an informative, well illustrated treatment. Two illustrated keys, one to whole bats, the other to skulls, are accompanied by range maps and detailed measurements of the species recorded from Canada.

Furthermore, the species accounts provide current information about their biology and distribution within Canada.

I was particularly favourably impressed because the information in the book is drawn from many recent studies of bats. Whether one is reading about echolocation or about reproduction, the latest works are cited. Not only has Dr. van Zyll de Jong put the material in a Canadian context, he has made it easy for a novice about bats to obtain a general introduction to them and to begin to explore the current literature about them.

Whether one wants to see which species of bats occur in Prince Edward Island, or what is known about the biology of *Myotis evotis*, this book is an ideal source. By asking field course students to use it, I have established that the illustrated key to whole

bats works well, even for species of *Myotis* that are superficially similar in appearance.

The book would have been more useful if it had included an index. The drawings of bats, whether coloured or black-and-white, are well done, but for some species these illustrations are less useful than the key when it comes to identifying a whole bat in the hand.

I highly recommend this book to anyone who is interested in bats in general or Canadian bats in particular. Whether you are a keen naturalist or someone teaching a class in mammalogy, van Zyll de Jong's book is for you.

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Listening in the Dark: The Acoustic Orientation of Bats and Man

By D. R. Griffin. 1958. Reissued 1986. Cornell University Press, Ithaca. 464 pp., illus. U.S.\$17.50.

In this book Donald R. Griffin explores the discovery of echolocation by man. The book focuses on bats and covers topics from laboratory studies to field research. The first chapter examines the nature of bats, from their wings and evolution to their economic and medical importance. The second chapter the "vital energetics" and migration of bats. Chapters 3 to 9 inclusive deal with different aspects of echolocation, from the history of studies of bat orientation to the behavioural performance of echolocating bats. Chapter 10 puts echolocation into a broader perspective, dealing with bat-moth interactions and the use of echolocation by marine mammals, while Chapter 11 discusses echolocation in oilbirds and cave swiftlets. The next two chapters address the possibility of echolocation by blind people, and artificial devices that might permit human echolocation. Chapter 14 considers the acuity of echolocation, particularly concentrating on the performance of bats in situations of high background noise. The last chapter reflects on the role of the experimental naturalist in modern science.

The writing is clear and easy to follow, although some may find it a bit technical. I am particularly enthusiastic about this book because it follows the development of an idea. At a time when it is easy to confuse technology with science, *Listening in the Dark* makes it clear that in the late 1700's the Italian Lazo Spallanzani had concluded that bats could "see with their ears". His conclusions were based on a series of experiments that manipulated the cues

available to the bats he studied. In *Listening in the Dark*, Griffin has demonstrated how technology permitted him and others to explore some of the ramifications of Spallanzani's conclusion.

Listening in the dark is a classic and its reprinting by Comstock/Cornell means that my students can get their own copies and I can replace my earlier worn edition. The foreword by James A. Simmons, one of the leading workers in echolocation today, permits a reader to appreciate some of the recent developments in echolocation and the depth of Griffin's perception.

Quite simply, everyone who is interested in bats and their orientation should read *Listening in the Dark*. It should also be reading required of biology students interested in animal behaviour. The book is FULL of interesting and exciting observations and often when you think that you have found something new about bats and echolocation, you read about it in *Listening in the Dark*. Just recently I experienced another of these situations when a colleague studying red bats in southwestern Ontario proposed that these bats eavesdropped on the echolocation calls of conspecifics to find vulnerable prey. Griffin discussed (page 200) this very possibility in red bats after observing them foraging over a miniature golf course.

I applaud the reprinting of this excellent book and recommend it as an informative and entertaining read.

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Field Guide to the Birds of North America

By National Geographic Society. 1987. Second edition. The National Geographic Society, Washington. 464 pp., illus. U.S. \$19.95 plus U.S.\$4.75 postage.

When the first edition of this guide was published in 1983, it was widely acclaimed in North America and reviewers, including myself (see *Canadian Field-Naturalist* 1986, 100: 291–292), were generally unanimous in considering it the best available guide to North American birds at that time in spite of few shortcomings. Four years later and after a sale of 375 000 copies, how is the second edition different from the first?

The general appearance of the book is the same, the number of pages remains at 464, and the artists and consultants are not different from those of the earlier edition. According to the publisher, 31 of the plates have been modified, but what a job it was to find which those plates are! A number of corrections, mostly minor but nevertheless useful or essential, have been incorporated in the plates of this edition. New species have been added to the plates of the first edition by rearranging the drawings on those plates or by redoing some of them entirely to accommodate the additions. The overall appearance remains excellent.

The loons (pp. 19, 21) have been improved considerably, particularly in the winter plumage; the bills as well as the colour and colouration patterns are now more accurate, and the Arctic Loon has become the Pacific Loon. The text and range map have been adjusted accordingly. The "light phase" of the Western Grebe (first edition) is now recognized as Clark's Grebe (p. 21), which reflects a change adopted by the A.O.U.; the illustration is the same as before but it has been relabelled. There is a new map and a new text for that "new" species.

Some plates have been redone entirely and replace earlier ones. Their quality is now much better and the accuracy of the illustrations far

superior to those of the first edition (pp. 230, 234, 236, 296, 298). Other plates have been changed also but to a lesser extent. The changes can be as minor as improving the colouration of the birds; which are now more life-like than before or to add a new species such as the Jackdaw (p. 306) or the Red-breasted Flycatcher (p. 321) without changing the other illustrations. Certain plates have been modified more significantly which results in greater accuracy in the depiction of birds difficult to identify. In the first edition certain field marks had been overemphasized and their representation was not realistic; these have now been adjusted. As an example, the flycatchers of page 293 had immense eye rings that one would never expect to find in the field. These have been adjusted to more realistic proportions.

The general colouration and colour saturation of the plates has been improved and the general effect is that the plates are less saturated, have softer tones, are more life like, and are more attractive and pleasant to consult.

The text has been modified and improved where necessary and the onomatopoeias representing call notes or songs have been changed in a few places. Similarly, the range maps have been corrected or improved for a number of species.

This second edition, with its improvements, remains the best field guide to North American birds currently available on the market. I highly recommend it to beginners as well as experienced birders.

NOTE: On peut obtenir une excellente traduction française de ce guide sous le titre: Guide d'identification des oiseaux de l'Amérique du Nord. Editions Marcel Broquet. 1987.

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Ducks of North America and the Northern Hemisphere

By John Gooders and Trevor Boyer. 1986. Facts on File, New York. 176 pp., illus. U.S. \$24.95.

Among the recent series of popular books on waterfowl, *Ducks of North America and the Northern Hemisphere* ranks as a must for the avid decoy carver, waterfowler, and naturalist, if only for the excellent illustrations by Trevor Boyer. The majority of the plates are outstanding! In this

work, 52 of the 59 species of ducks which occur north of the equator are described.

This book combines the page layout of a field guide with the style of a standard text. Each species description incorporates a distribution map, a list of vital statistics, and excellent plates. The small maps show the extent of breeding and wintering ranges. The common and scientific names are a neatly offset caption. This is followed by a

distinctively coloured box with pertinent statistics such as body and wing measurements, egg colour, clutch size, and incubation and fledging periods. The accompanying text is an expansion of this succinct capsule: anecdotal information covers distribution, populations, habitat use, feeding, winter areas, moult migration, nest structure and location, and the activities of young. Small marginal figures provide useful field marks for identifying males and females on the wing. Each species is either illustrated on a full page showing both sexes or portions of a page, usually depicting the male, although in some cases the pair is shown.

Several of the New World species do not appear, including the White-cheeked Pintail (*Anas bahamensis*), West Indian Whistling-Duck (*Dendrocygna arborea*), White-faced Whistling-Duck (*Dendrocygna viduata*), and Muscovy Duck (*Cairina moschata*) (R. S. Palmer. 1976. *Handbook of North American Birds*. Volumes 2 and 3. Yale University Press, London; P. A. Johnsgard. 1968. *Waterfowl: Their Biology and Natural History*. University of Nebraska Press, Lincoln; and AOU. 1983. *The Check-List of North American Birds*. Sixth edition). The Mexican (*Anas diazi*) and Mottled ducks (*A. fulvigula*) are considered by some as forms of the "Mallard" group, *A. platyrhynchos*, (P. A. Johnsgard. 1975. *Ducks, Geese and Swans of the World*. University of Nebraska Press, Lincoln; AOU Check-list, 1983); these receive minimal consideration. Although this treatment is acceptable, a discussion of these "forms" and other forms would have enhanced the reader's understanding of the Mallard complex. Palearctic species absent from this work include the Cape Teal (*Anas capensis*) and the Spur-winged Goose (*Plectropterus gambensis*) which are described in Cramp et al., (1977. *Handbook of the Birds of Europe, the Middle East, and North Africa: the Birds of the Western Palearctic*. Volume 1. Oxford University Press, Oxford), both of which breed within the northern hemisphere.

Concern is expressed for the populations of Canvasback (*Aythya valisineria*), Redhead (*A. americana*), and Ruddy Duck (*Oxyura jamaicensis*). Populations of these species have been highly variable over the last 25 years and, although none is threatened, hunting mortality and the quantity and quality of both wintering and breeding habitat have affected their numbers. Ruddy Duck averaged 520 000 through most of the 1960s and 1970s declining to 268 000 in 1976, then rising to 1.3 million in 1982, only to decline to 600 000 by 1985 (USFWS/CWS survey data, Dale Caswell, personal communication).

Other observations about this book include: (a) Blue-winged Teal (*Anas discors*) has probably never been observed to perch on the branches of shrubs which overhang the water of prairie ponds contrary to the suggestion in the text; (b) the major plates are unlabelled; (c) the species name of the Spot-billed Duck (*Anas poecilorhyncha*) is incorrectly spelled in the caption; and (d) illustrations of downy young would have been a plus.

The authors have done a poor service to their European audience by omitting several major references which would be invaluable to those readers wishing to have a better understanding of the ecology of North American waterfowl. Several of these references appear above while others which should be included are Bellrose (1980. *Ducks, Geese and Swans of North America*. Stackpole Books, Harrisburg, Pennsylvania) and Godfrey (1986. *The Birds of Canada*. National Museums of Canada, Ottawa).

Those interested in excellent illustrations of ducks and a condensed overview of individual life histories should find this book a useful and convenient resource.

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Harrier, Hawk of the Marshes: The Hawk that is Ruled by a Mouse

By Frances Hamerstrom, illustrations by Jonathan Wilde, photographs by Frederick Hamerstrom, and foreword by Roger Tory Peterson. 1986. Smithsonian Institution Press, Washington. 171 pp., illus. Cloth U.S.\$24.95; paper U.S.\$10.95.

In this attractive little book the author describes her "voyage of discovery as" she "gradually learned

about the relationships between voles (or meadow mice, as they are sometimes called) and the harrier, a hawk of the marshes". This adventure lasted 25 years and resulted in a number of scientific papers by the author and her collaborators, in addition to the present book in which the life history of the Northern Harrier (*Circus cyaneus*), formerly

called in North America the Marsh Hawk, is treated at length in a popular fashion. There are 22 short chapters, followed by an epilogue, a bibliography, an appendix, and an index.

The book is an unpretentious account of the author's observations in a lively style. Although the contents could have been like scientific papers usually are, Mrs. Hamerstrom describes her findings in a pleasant, sometimes humorous manner. Because of the scope of the book, which appears to be directed at a general audience, the author does not go into details on the results of her work. However, biologists and ornithologists, as well as naturalists and the public in general, will find in this book a great deal of interesting and useful information about the Northern Harrier. Some of the anecdotal material is funny in several instances.

Topics such as mating, trapping and marking, nest finding, field identification, sexing, mice,

DDT, training of assistants, etc., are treated, some of them to a greater extent than the others. Of particular interest is the finding of the effects of DDT on both harriers and voles, and particularly on the breeding behaviour of harriers. Few references are made to the published works of the participants to the project, and other important works on harriers do not appear in the bibliography.

In spite of minor shortcomings, the book well deserves to be purchased particularly if one does not expect a highly technical scientific report. I therefore recommend it to all those interested in knowing more about the Northern Harrier.

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Wasp Farm

By Howard Ensign Evans. 1985. Comstock (Cornell University Press), Ithaca. x + 178 pp., illus.

In eastern Canada, the summer of 1987 was long, warm, and good for wasps. Paper wasps were especially abundant, creating problems for telephone and electrical line workers who, while inspecting junction boxes and similar installations, experienced first-hand, and atop ladders, their fierce defensive attacks. Homeowners, picnickers, and campers were pestered by these zesty, and to some, menacing, uninvited guests to outdoor meals. To the true and dedicated naturalists, those annoyances are forgotten in the fascination of observing the wasps' behaviour and musing on how the lives of the wasps might have been without human benefactors for food and nesting sites, and how the complexities of their social organization might have come about.

Professor Evans richly describes the lives of wasps. He unfolds for the readers of his book, not just the biology of his subjects, but weaves his personal curiosity and love for nature into his graphic accounts. His story is not just about the kinds of wasps I have mentioned above (i.e. some of the vespids), but also about the spider wasps (pompilids), digger wasps (sphecids), and other vespids. He has arranged the book in an evolutionary sequence from primitive to advanced, and has avoided narrowly technical discussions and details of wasp systematics. His highly readable account is based on his years of

observations from an eight acre farm, "Wasp Farm", in upstate New York. He has embellished those with descriptions from the lives of wasps of the Gulf Coast, from the Southwestern Deserts and Mountains, and from the more northerly Badlands and Prairies, with occasional glimpses of wasps from the Tropics.

To arouse the curiosity of readers of this review, I provide a brief precis of some highlights. The spider wasps (Pompilidae) are not restricted to using spiders as prey, as their name might imply. Nevertheless, many species do restrict themselves to capturing and stinging spiders which they hide in burrows and upon which they lay their eggs. Their prey is for their progeny. The diversity of life styles shown by these wasps is great, but not so much as that of the "thread-waisted" digger wasps (Sphecidae). Those tend to specialize on capturing and stinging grasshoppers and caterpillars upon which to lay their eggs. The males of sand wasps, *Bembix* (also Sphecidae), often form aggregations flying low over sandy soil from which their prospective mates will emerge. Those wasps are not so thread-waisted and look similar to paper wasps. The females, after mating, provision their excavated underground cells with such prey as flies. The mud-daubers are also sphecids. By mixing mud and saliva, they build an array of different sorts of nests, depending on the species. They may build their architecturally intricate nests in conspicuous places on walls, beneath eaves, and

in attics. Other mud users are the mason wasps, which although solitary are in the same family (Vespidae) as the paper wasps. Many use mud to build partitions between the cells in their tunnel nests in hollow twigs, beetle mines in fence posts, and similar places. The potter wasps (*Eumenes*) also belong to this group and build elegant narrow-necked jugs which they attach to twigs. As Professor Evans explains, it is not a long step from mixing mud and saliva to mixing punky wood and saliva to make paper by which the "Stately Mansions" of the hornets or yellow jackets are built.

The book describes these marvelous creatures and delves into the intricacies of their life histories, strategies for survival, and deviousness in avoiding their own predators and parasites. The chapters have tantalizing titles . . . "Stinkbugs for Dinner", "Thirteen Ways to Carry a Dead Fly" . . . and bring the reader to the evolutionary prospect of these often inconspicuous, and usually not numerous, predators. A chapter devoted to how to attract wasps explains the simple ways one can use to "trap-nest" these creatures to watch their activities and further one's appreciation of these resourceful insects. The final chapter, "The Long

Road to Failure" serves to emphasize that it was through a wasp-ancestor that the more ubiquitous and numerous bees and ants arose. But I disagree with Professor Evans that the "Road", even within the wasps, has been one to "Failure".

The book has itself, like the wasps, endured. It was first published over twenty years ago and is as scientifically accurate now as it was then. A rich area of more recent scientific controversy has been that of Sociobiology. Because the subjects of this book span the gamut from non-social to truly social insects, a chapter on that subject airing Professor Evans' views and profound understanding of wasps would have been welcome reading.

For myself, I should have read this book while I was a student. It has been a delight to read it for this review. I am sure that all field naturalists will enjoy Professor Evans' vivid reflections of nature, the accuracy of his science, and the readability of his prose. Wasp-watching is a relaxing way to discover intricate diversity in nature, and this book provides the basis to start.

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Birdwatching in Britain: A Site by Site Guide

By Nigel Redman and Simon Harrap. 1987. Christopher Helm, London. 378 pp., illus. Cloth £12.95.

Visiting birders to Britain need two books. First they must have a field guide, of which there are several excellent ones to choose from. Second, the birders need a copy of *Birdwatching in Britain*. This excellent site guide gives all the necessary information on Britain's better birdwatching sites.

The authors did not write this book for the hardcore "twitchers" (the fanatic, competitive listers), but for the British enthusiast and the visitor. They have not confined themselves to the most exotic and well-known places but have included many worthwhile spots. This means a visitor can plan major trips to the famous places and can select more local areas for short side trips.

I have checked much of the access, and habitat information and the data on types of birds found, and it is accurate and up-to-date. The book is well designed and written, so it is easy to look up information and develop good birding plans. The maps, by Robert Thorn, are well done; being clear and functional (references are given for topogra-

phic maps, where appropriate, but it is not necessary to get these). There is a useful species list that is cross-referenced to the sites. Generally, the commoner and scarcer species are the ones discussed. Rarities are too erratic to fit into a book of this format. Many of the more interesting species are illustrated with delightful line drawings by Craig Robson.

It has been 20 years since John Gooders (1967) brought out his classic site guide, and this book is now out of date. The authors have not only brought us up-to-date but have given us a better quality book. I thoroughly recommend it to any North American visiting Britain. In fact, it is so good I suspect that a lot of British "twitchers" will buy it too.

Literature Cited

Gooders, John. 1967. Where to watch birds. Andre Deutsch, London, England.

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BOTANY

The Savannas: Biogeography and Geobotany

By Monica M. Cole. 1986. Academic Press (Canadian distributor, Harcourt, Brace, Jovanovich, Don Mills, Ontario). 438 pp., illus. \$115.50.

This book differs from other published works about tropical savanna ecology. The other works focus on ecosystem dynamics and functions and on human ecology while the objective of this book, in Cole's own words, is to "... provide a framework within which the relationships between the distributions of the major categories of savanna, the vegetation associations, and the plant communities within them and the environmental conditions can be understood, and the precise relationships between the vegetation and the interplay of individual environmental parameters can be investigated and evaluated."

The author has spent over thirty years investigating tropical savannas in Africa, South America, and Australia. She has found that climatic changes, geological events, geomorphological evolution, geologic parent material, and the resulting soils are the major environmental parameters that govern the distribution of tropical savanna vegetation. The biogeographies of large study areas from three continents are described in terms of the above factors. Most of the information presented comes from the author's own field research.

The focus is on the distribution of the major savanna categories, vegetation associations, and plant communities. It is refined to the individual species level in the cases of species that are indicators of valuable mineral deposits and concentrators of toxic elements in various soils. The relationship between the geology-related environmental parameters and plant distribution is described many times without very many detailed physiological explanations.

In part one of this six part book, the various classification schemes for tropical savanna vegetation are reviewed, and the author's own classification system is presented. This review is followed by another which is about the environmental factors that influence the distribution of savanna vegetation. The relatively simple savanna distributions in South America are described and explained in part two. Part three, by far the book's largest part, explains the complex savanna

distributions in parts of Africa. This is followed by a brief account of tropical savannas in India and Southeast Asia in part four and by a more detailed account of the wide variety of savannas in Australia in part five. Many parallels are drawn between the savannas of Africa and Australia where a number of geologic events such as crustal warping have occurred since the break-up of Gondwanaland in the late Cretaceous. These two continents are contrasted with South America where the ancient planation surfaces have not been subjected to such dramatic events. Part six reviews the value of the knowledge of the relationship between tropical savanna vegetation and the geomorphological environment for planning agricultural uses, mineral exploration and development, and road construction.

Probably the greatest general interest value to be gained from this paper is an appreciation for how most tropical savannas occur on ancient, impoverished, lateritic soils that date back to Tertiary times when these soils developed under rain forest. They were heavily leached under these conditions. Only limited areas within the tropical savannas contain fertile soils derived from more recently exposed bedrock. In fact, it was startling to learn of the author's suggestion that the erosion of the ancient Tertiary soils is necessary for the exposure of nutrient-rich parent material that can weather into new, nutrient-rich soil.

This book does succeed in reaching its objective of describing the complex relationship between the distribution of savanna vegetation and the major environmental parameters that govern that distribution. Botanists and plant ecologists may find the book's heavy dose of geology and geomorphology a little tedious but not impossible to follow (the author is a member of the University of London's Department of Geography). This book is for 1) those interested in the relationships between geomorphology and tropical savanna vegetation and for 2) those interested in an introduction to tropical savanna vegetation that is not burdened with detailed phytosociological data.

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Botanical Illustration: Preparation for Publication

By Noel H. Holmgren and Bobi Angell. 1986. New York Botanical Garden, Bronx. 74 pp., illus. U.S. \$12 in the U.S.A.; U.S. \$13 elsewhere.

The authors of this attractive and inexpensive little handbook have focused on botanical illustration. However, much of what is contained within these pages applies equally well to entomological or indeed any technical illustration.

The stated aim of this book is to improve the quality of illustrative work submitted with professional papers. Therefore, this is not a book for the amateur sketcher of plants. It is, rather, addressed to the professional researcher or graduate student, to the professional or student illustrator, and to editors. The topics covered are the relationship between the author and the artist, materials and tools, appropriate captions and figure labels, maps, photographs and other halftone work, and preparation for shipping.

This book is in fact a plea for the recognition of the importance of appropriate illustrations to enhance the communication of research, particularly taxonomic research. It is a plea to assign an adequate portion of the research budget for the necessary artistic work. So, rather than offering tips on improving one's illustrations, the authors have presented us with examples of beautifully detailed drawings, and explained the reproductive costs and the cost of materials involved in producing such art work. This tends to put off or intimidate poorly funded researchers while it just might encourage the better funded to pay for a professional artist.

The chapter on the relationship between the artist and the author includes a discussion and

explanation of U. S. copyright law. I found this to be the very interesting, never having come across this information in other books on technical illustration.

The very complete discussion of tools and materials alerted me to the availability of such items as electric erasers and mechanical pencil point sharpeners. But careful browsing through a well-equipped art supply store would have given me the same information.

My biggest quibble with this book is the serious underestimation of the time it takes to produce the illustrations in the examples given. I cannot believe that in 3½ hours, for instance, an artist can produce the detailed set of inked drawings as in Figure 10, or that in 1½ or 2 hours, respectively, even a professional artist could produce the beautiful pencil illustrations shown in Figures 11 and 12. I am told that the costs from the printer for photography and proofs are also somewhat underestimated.

Handsome as it is, this book is not particularly useful to the scientist wishing to personally improve upon his or her drawings. Other books, or indeed studying published illustrations, would be more helpful. However, this book might be useful for the beginning technical illustrator, concentrating as it does on what such work entails. It is probably too elementary for the established professional artist.

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Flora of New Zealand: Lichens

By David J. Galloway. 1985. New Zealand Government Printer, Wellington. lxxiii + 662 pp., illus. NZ \$39.95.

It is probably fair to say that our cataloguing of the lichens of Canada, as of the temperate, boreal, and arctic parts of the northern hemisphere in general, is finally nearing completion. The situation, however, is very different in most other parts of the world. In fact, in the entire southern hemisphere there has not yet appeared, except for Antarctica, a single comprehensive guide to the lichens of any major region. Until now.

David Galloway's *Flora of New Zealand Lichens* is clearly an epoch-making publication in

its field. Though it is, as the author readily admits, a "warts and all" summary of New Zealand's lichen flora, covering perhaps no more than 60% of the species actually present, it does manage to assemble into one volume accounts of all the 958 taxa thus far known to occur here. What is more, its usefulness extends far beyond the boundaries Galloway has set for it. It provides, very probably, a rough guide to the lichens of the southern hemisphere in general.

For the most part the introductory sections are fairly standard for a work of this kind. Two innovations, however, can be mentioned. First, the book includes a comprehensive listing of titles

pertinent to the taxonomy of New Zealand's lichens. Chronologically arranged, this survey effectively complements the brief historical account which precedes it, at the same time providing an open sesame to future floristic studies.

The second innovation, more limiting than helpful, involves a complete lack of any introduction to lichen morphology, anatomy, or chemistry. In short, the user of this book, if he is not already conversant with standard lichenological terminology, will be obliged to become so prior to consulting it. For this reason, it can be predicted that *Flora of New Zealand Lichens* will not receive full attention by amateur naturalists, though admittedly Galloway does provide a glossary, and directs the reader to some basic introductory references.

The body of the text consists of alphabetically arranged genus accounts and, intercalated with these, species keys and descriptions. On the whole the keys are terse, at times even telegraphic, but apparently serviceable in the identification of typical material. As to the species descriptions, these vary considerably in detail from group to group, apparently relying rather heavily on previously published data. Still, within each genus Galloway seems to have taken pains to provide standardized descriptions — a point which will be much appreciated by those attempting to determine which characters are diagnostic and which are not. For each species, brief notes on world distribution, status in New Zealand, ecology and taxonomy are also provided.

The taxonomy is progressive: included are a number of recently described genera, some of which apparently have not appeared in previous floras. Ironically, one disadvantage of this state-of-the-art approach is that, at a time when new lichen genera are being segregated almost daily, it destines the book to be out-of-date as soon as it is off the press. Perhaps a more conservative genus concept, though less phylogenetically revealing, might have introduced more stability into the text — at least for the present.

At this point the question may be asked: "What possible interest could the publication of a book on New Zealand's lichens hold for the Canadian naturalist?"

On the face of it, not much. However, perhaps it can be noted that at least some of the keys included here serve passably well for the identification of our own lichen species, notably in the genera *Chaenotheca*, *Cladonia*, *Calicium*, *Parmotrema*, *Pseudophebe*, and *Umbilicaria*. In fact, a quick tally shows that approximately 20% of the lichens listed as occurring in New Zealand occur also in Canada — at its antipodes! This figure is the more astonishing when it is realized that similarly ubiquitous species are virtually nonexistent in most other life forms. Thus, *Flora of New Zealand Lichens* promises to yield fertile ground for those interested in probing the evolution of life, and the history of its distribution across the face of our globe.

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A New Key to Wild Flowers

By J. Hayward. 1987. Cambridge University Press, New York. 278 pp., illus. U.S.\$49.50.

Residents of Great Britain and visitors to that country who are interested in learning the names of the plants around them will find this book of simple keys to wildflowers most useful. The biggest problem with it is that the area that it covers is not mentioned either in the title or the introductory text, a real problem when it is published by Cambridge University Press of Cambridge, London, New York, New Rochelle, Melbourne and Sydney, and will probably be offered for sale throughout the English speaking world.

Introductory materials include a short preface which explains why the keys were developed, a note on the AIDGAP project, which is a project "designed to help biologists with groups in which the difficulty is due to the absence of a simple and easy-

to-use key", instructions on how to use the key, some general notes, an illustrated glossary, and a list of abbreviations used throughout the text.

To use the keys one must first turn the book so that it is at right angles to the way a book is normally held. This allows space for four columns of multiple choices plus a reference to a page if required, as in the section that leads to the families, or the name of a particular species within a family. Lines across or part way across the pages separate the characters that apply to a given species.

The language used in the keys is non technical. The keys are not strictly dichotomous as in most floras, but rather, the user must make choices where the characters used to separate groups or species not necessarily close together taxonomically are separated, and must assume that when a choice is made the characters used above to distinguish one

plant do not apply to the plants below as he proceeds down the column. Thus in Section 2 of the family Compositae there are 11 choices in the first column ranging from "Stems w. many scales but no true lvs.", which leads to *Tussilago farfara*, Colt's foot, to "Ray florets short, almost erect", which leads to *Pulicaria vulgaris*, Small Fleabane. Excellent small line drawings illustrating habit, leaf shapes, flowers, fruits and other features are found throughout the keys where such demonstrations are required. There are no generic or specific descriptions, and no

synonyms to Latin names, but rather reference is made to the general works of Clapham, Tutin, and Warburg, and several handbooks on specialized groups such as grasses, for more advanced work and comprehensiveness. An index to common and scientific names and an index to families complete the work.

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ENVIRONMENT

A River No More: The Colorado River and the West

By Philip L. Fradkin. 1984. (1981). The University of Arizona Press, Tucson. 360 pp., illus. U.S. \$10.95.

It was prehistoric Indians who first began to control the flow of water within the Colorado River Basin, perhaps as early as 200 B.C. By the 12th century A.D. the Anasazi Indians of what is now New Mexico and the Hohokam Indians of today's Arizona had constructed extensive water distribution systems that would not be surpassed for several centuries. The decline of the communities based on these systems was due in part at least to overuse of water, which in combination with the destruction of the vegetation cover led to disastrous floods, and to salinization and water-logging of the soil.

With the coming of European settlers, hydraulic engineering was resumed on a vastly larger scale, so that within a few generations the Colorado has become, almost literally, *A River No More*. Water was first diverted for irrigation, leading incidentally to the creation of that strangest of man-made lakes, the saline Salton Sea, produced when the accidental breaching of dykes allowed the main flow of the Colorado River to run from 1905 until 1907 into an ancient lake bed. Then water was diverted for urban and industrial use, and great dams were built to generate electricity, creating more lakes. The first of these dams, Hoover, was one of the proudest engineering achievements of the Great Depression. Now it provides electricity for the neon lights of Las Vegas, among other purposes, and its reservoir, Lake Mead, provides an opportunity for fishing and water sports for those who do not care for gambling. Then came Parker Dam, Glen Canyon Dam, Flaming Gorge Dam on the Green River, and a number of others, so that long stretches of what was once running water have been converted to lakes.

The author has travelled most of the length of the river system, from its beginnings in the mountains of Wyoming and northern Colorado, through the desert as the quantity and quality of its water steadily decline, to the shallow ponds where the last depleted flows evaporate, only occasionally trickling into the Gulf of Mexico. In his account of his travels he provides us, like Huckleberry Finn in his trip down the Mississippi, with a fascinating panorama of present-day life along the river, as well as intriguing glimpses of its past. Explorers, trappers, and miners; Indians, Mexicans, and Mormons; ranchers, developers, and conservationists; gunmen and lawmen; all these have played their parts in making the Colorado River Basin what it is today. And of course there were the politicians; lots of politicians.

The author describes a day in the hectic life of Leonard Schaffer, a ditch tender in the Imperial Valley, whose responsibility it is to open and close sluice gates in order to manipulate the flows through the irrigation system to ensure that the farmers of the area get the quantities of water that they require. Very different is the life of Grant Jones, which the author also describes. He spends his days in the dark and chilly interior of Powell Dam, recording the readings of strain gauges and measuring rates of seepage.

Anyone at all interested in rivers will find much to enjoy in this book, although Canadian readers may find some of the accounts of political maneuvering a little tedious. The author writes well, and his tone is reasonable and not at all polemical. As he points out in his preface, he offers no specific solutions, but hopes that widening the debate on western water resources may lead eventually to fair and rational solutions. Canadian

readers may be surprised to learn that Water Law in the western United States is based on the doctrine of prior appropriation, rather than the more familiar doctrine of riparian rights. They may be shocked at the vigorous way in which certain individuals have defended what they have seen as their rights under the law. Armed confrontations have occurred more than once, and troops have been called out on occasion.

The author refers briefly to the notorious North American Water and Power Alliance plan, which

would transfer water from northwestern Canada through the Rocky Mountain Trench to the United States. If this plan ever begins to receive serious consideration, Canadians would do well to read this book for the insight it can provide into the way of thinking of many western Americans in matters concerning water.

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The Urban Naturalist

By Steven D. Garber. 1987. Wiley Science Editions. John Wiley and Sons, New York. xiv + 242 pp., illus. U.S.\$12.95.

This is an attractive book which discusses the city as an ecological habitat and depicts many species that live there. It should appeal to naturalists, describing as it does in a page or two the commonly noted species of plants (16 groups of grasses, wildflowers, and trees) and animals (many more invertebrates and vertebrates) found in American cities. Most of the species discussed live in Canada, too, but other common Canadian species such as the American robin and maple trees are only mentioned in passing.

Such a book as this could be merely a compendium of species' descriptions, but Garber goes far beyond this. He includes historical information on how particular alien species arrived in America and became distributed there, and he speculates on why they may have had success or otherwise living in cities. For example, he notes that bedbugs may be less common than formerly both because there are fewer wooden beds and because central-heating may sometimes confuse their heat-seeking sensors so that they are unable to find human hosts.

Garber incorporates little-known facts into the text, although these are not specifically referenced to enable the reader to find out more about them. We learn that Bullfrogs thrive in urban ponds where waterfowl excrement ensures rich nutrients: the fish are often too stunted in growth to eat the tadpoles and the water tends to be murky, thwarting avian predators such as herons; that house flies can carry and transmit over 100 disease-causing pathogens as well as parasite eggs; that some tent caterpillars are leaders, striking out from their warm tents on their own, while others will

only follow silken trails which these adventurers lay down; that snakes which bear their young alive, like garter snakes, have an advantage in cities because the female does not have to dig into the compacted earth to lay eggs; and that many turtles do well in city parks because people are too afraid of muggers to go there at night when they would disturb the turtles' egg-laying. There is a great deal of information about birds and mammals, too, with which readers will be more familiar.

The author wants to work with nature as far as possible, not against it. He reports that poisoning rats in New York city has made some bolder rather than exterminated them, and is against spraying biocides indiscriminately because of the wide-ranging harm they can do. He wisely suggests that a body repellent against mosquitoes which contains the chemical DEET is better than spraying urban areas, but he does not mention that DEET is a carcinogen. Unfortunately he sees no harm in sport fishing, and describes the sunfish as a good "beginner's fish" often caught by children.

The Urban Naturalist is attractively illustrated by Jerome Lo, with many line drawings of species but little other information that would enable one to classify individuals by this book alone. However, it uses the scientific name of the plants and animals it discusses, so that further information can easily be obtained elsewhere. The book includes an extensive index and a large reference list of books for additional reading, and is almost free of sexist language. For those who are planning to turn their attention to the life around them in the city, this is a good beginning book.

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NEW TITLES

Zoology

- Animal conflict.** 1987. By Felicity A. Huntingford and Angela K. Turner. Chapman and Hall, New York. 448 pp., illus. Cloth U.S.\$55; paper U.S.\$25.
- The archaeology of animals.** 1987. By Simon J. M. Davis. Yale University Press, New Haven. 224 pp., illus. U.S.\$27.50.
- ***Audubon wildlife report 1987.** 1987. Edited by Roger L. Di Silverstro. Academic Press (Canadian distributor, Harcourt Brace Jovanovich, Don Mills). 690 pp. U.S.\$39.95; \$59.25 in Canada.
- The beginning of the age of dinosaurs: faunal change across the Triassic-Jurassic boundary.** 1987. Edited by Kevin Padian. Based on a symposium, Berkeley, October, 1984. Cambridge University Press, New York. xii + 378 pp., illus. U.S.\$75.
- The boundary biology of aggression.** 1988. By John Archer. Cambridge University Press, New York. c260 pp., illus. Cloth cU.S.\$44.50; paper cU.S.\$17.95.
- Biography and taxonomy of honeybees.** 1987. By F. Ruttner. Springer-Verlag, New York. c290 pp., illus. cU.S.\$99.50.
- Birds by the Dempster Highway.** 1987. By Robert Frisch. Second edition. Morriss, Victoria (Yukon Conservation Society, Whitehorse). \$5 + \$1.50 postage.
- Birds of Yosemite and the eastern slope.** 1988. By David Gaines. Artemisia Press, Lee Vining, California. c232 pp., illus. U.S.\$14.50.
- †**Bison ecology in relation to agricultural development in the Slave River lowlands, NWT.** 1987. Edited by H. W. Reynolds and A. W. L. Hawley. Canadian Wildlife Service Occasional Publication No. 63. Environment Canada, Ottawa. 74 pp., illus.
- ***Community and evolutionary ecology of North American stream fishes.** 1987. Edited by William J. Matthews and David C. Heins. University of Oklahoma Press, Norman. 384 pp., illus. U.S.\$42.50.
- Community ecology and salamander guilds.** 1988. By Nelson G. Hairston, Sr. Cambridge University Press, New York. 240 pp., illus. U.S.\$54.50.
- Distributional checklist of North American birds.** 1986. By David DeSante and Peter Pyle. Artemisia Press, Lee Vining, California. 456 pp., illus. U.S.\$30.
- ***The eagle's nest: natural history and American ideas, 1812-1842.** 1986. By Charlotte M. Porter. University of Alabama Press, Tuscaloosa. 304 pp. U.S.\$24.95.
- Ecological studies in tropical fish communities.** 1987. By R. H. Lowe-McConnell. Cambridge University Press, New York. xiv + 382 pp., illus. Cloth U.S.\$64.50; paper U.S.\$22.95.
- ***Endangered species: Canada's disappearing wildlife.** 1987. By Clive Roots. Fitzhenry and Whiteside, Markham, Ontario. 96 pp., illus. \$22.50.
- Evolution of longevity in animals: a comparative approach.** 1987. Edited by Avril D. Woodhead and Keith H. Thompson. Proceedings of a symposium, Upton, New York, 19-22 October, 1986. Plenum, New York. c354 pp. U.S.\$59.50.
- Fishery development.** 1987. By William F. Royce. Academic Press, (Canadian distributor, Harcourt Brace Jovanovich, Don Mills, Ontario). 187 pp. U.S.\$24.95.
- Flattened fauna: a field guide to common animals of roads, streets, and highways.** 1987. By Roger M. Knutson. Ten Speed Press, Berkeley. 88 pp., illus. U.S.\$4.95.
- Insect dormancy: an ecological perspective.** 1987. By H. V. Danks. Biological Survey of Canada, Ottawa. x + 439 pp., illus. \$50.
- An international history of mammalogy, volume 1: eastern Europe and Fennoscandia, 1.** 1987. Edited by Keir B. Sterling. One World Press, Bel Air, Maryland. xxvi + 198 pp., illus. Cloth U.S.\$25; paper U.S.\$20.
- An introduction to animal law.** 1987. By Margaret E. Cooper. Academic Press (Canadian distributor, Harcourt Brace Jovanovich, Don Mills, Ontario).
- ***Inventory and monitoring of wildlife habitat.** 1986. Edited by Allen Y. Cooperrider, Raymond J. Boyd, and Hanson R. Stuart. U.S. Department of the Interior, Denver. xviii + 858 pp., illus. U.S.\$38.
- Invertebrate relationships: patterns in animal evolution.** 1988. By P. G. Willmer. Cambridge University Press, New York. c300 pp., illus. Cloth cU.S.\$45; paper cU.S.\$14.95.
- Living with seabirds.** 1987. By Bryan Nelson. Edinburgh University Press, Edinburgh. vii + 253 pp., illus. U.S.\$25.
- Lovebirds, cockatiels, budgerigars: behavior and evolution.** 1987. By J. Lee Kavanau. Science Software Systems, Los Angeles. xxvi + 1001 pp. U.S.\$69.
- †**Mammalian dispersal patterns: the effects of social structure on population genetics.** 1988. Edited by B. Diane Chepko-Sade and Zuleyma Tang-Halpin. University of Chicago Press, Chicago. xviii + 342 pp., illus. Cloth U.S.\$55; paper U.S.\$19.95.

Mediterranean marine avifauna: population studies and conservation. 1986. Edited by Medmaravis and Xaver Monbailliu. Springer-Verlag, New York. xx + 535 pp., illus. U.S.\$13.40.

***Population ecology of the cooperative breeding acorn woodpecker.** 1988. By Walter D. Koenig and Ronald L. Mumme. Monographs in Population Biology, 24. Princeton University Press, Princeton. xiii + 435 pp., illus. Cloth U.S.\$55; paper U.S.\$16.95.

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TABLE OF CONTENTS (concluded)

First nesting of the Glossy Ibis, <i>Plegadis falcinellus</i> , in Canada	DONALD MCALPINE, JAAKO FINNE, SCOTT MAKEPEACE, SCOTT GILLILAND and MARK PHINNEY	536
Bowhead Whale, <i>Balaena mysticetus</i> , sightings off the coast of Manitoba	PAUL D. WATTS	538
Hedge Woundwort, <i>Stachys sylvatica</i> (Labiateae) in Canada	J. K. MORTON	539
Brown Bear, <i>Ursus arctos</i> , with six young	RANDALL J. WILK, JOHN W. SOLBERG, VERNON D. BERNES and RICHARD A. SELLERS	541
Colonization of Snow Bunting, <i>Plectrophenax nivalis</i> , nests by bumblebees, <i>Bombus polaris</i> , in the High Arctic	OLGA KUKAL and DONALD L. PATTIE	544
A second record of the Mosquito Fern, <i>Azolla caroliniana</i> , in Ontario	WILLIAM J. CODY and FREDERICK W. SCHUELER	545
A range extension for the crayfish, <i>Orconectes rusticus</i> : Sibley Provincial Park, northwestern Ontario	WALTER T. MOMOT, CONNIE HARTVIKSEN, and GEORGE MORAN	547
New station for <i>Malaxis paludosa</i> , Bog Adder's-mouth Orchid, in northwestern Ontario	CHRISTOPHER A. ZOLADESKI	548
Suppression of reproduction in Upper Michigan White-tailed Deer, <i>Odocoileus virginianus</i> , by climatic stress during the rut	LOUIS J. VERME and ROBERT V. DOEPKER	550
Late breeding in the White-tailed Deer, <i>Odocoileus virginianus</i> , in northern Minnesota	KENNETH D. KERR and WILLIAM J. PETERSON	553
News and Comment		
Errata — Alfred Bog Fund		554
Restoring the Great Lakes — Means and ends	MICHAEL GILBERTSON	555
John Richardson: Deserving of greater recognition	C. STUART HOUSTON	558
A tribute to Austin Loomer Rand, 1905-1982	W. EARL GODFREY	564
A Canadian bibliography of Austin L. Rand	FRANCIS R. COOK and W. EARL GODFREY	567
A tribute to August Julius Breitung, 1913-1987	VERNON L. HARMS	572
Minutes of the 109th Annual Business Meeting of the Ottawa Field-Naturalists' Club 12 January 1988		578
Book Reviews		
Zoology: Seabirds of the World: A Photographic Guide — Diving Birds of North America — A Guide to Animal Tracking and Behavior — Animal Signatures — Animal Intelligence: Insights into the Animal Mind — An Introduction to Behavioural Ecology — The Encyclopedia of Animal Behavior — Butterflies and Moths — Eider Ducks in Canada — The Biology of Australasian Frogs and Reptiles — Handbook of Canadian Mammals, 2: Bats — Listening in the Dark: Acoustic Orientation of Bats and Man — Field Guide to the Birds of North America, Second Edition — Ducks of North America and the Northern Hemisphere — Harrier, Hawk of the Marshes: The Hawk that is Ruled by a Mouse — Wasp Farm — Birdwatching in Britain: A Site by Site Guide		587
Botany: The Savannas: Biogeography and Geobotany — Botanical Illustration: Preparation for Publication — Flora of New Zealand: Lichens — A New Key to Wild Flowers		600
Environment: A River No More: The Colorado River and the West — The Urban Naturalist		603
New Titles		605

Mailing date of the previous issue: 102(2): 5 December 1988

Articles

- Cougar, *Felis concolor*, sightings in Ontario HELEN B. GERSON 41
- Behavior responses and reproduction of Mule Deer, *Odocoileus hemionus*, does following experimental harassment with an all-terrain vehicle
CORNEL YARMOLOY, MAX BAYER, and VALERIUS GEIST 42
- Cherry depredation by Ring-billed Gulls, *Larus delawarensis*, in the Niagara Region, Ontario H. BLOKPOEL and J. STRUGER 43
- Habitat use, behaviour, and management of Trumpeter Swans, *Cygnus buccinator*, wintering at Comax, British Columbia R. W. MCKELVEY and N. A. M. VERBEEK 43
- Parasitic fungi of Newfoundland based on specimens from Gros Morne National Park J. A. PARMELEE 44
- Colony size and reproductive biology of the Bank Swallow, *Riparia riparia*, in Saskatchewan DALE G. HJERTAAS, PAULE HJERTASS, and WILLIAM J. MAHER 46
- Significant aggregations of the endangered Right Whale, *Eubalaena glacialis*, on the continental shelf of Nova Scotia GREGORY G. STONE, SCOTT D. KRAUS, JOHN H. PRESCOTT, and KATHERINE W. HAZARD 47
- New distribution records for the minnows *Hybognathus hankinsoni*, *Phoxinus eos*, and *P. neogaeus* in Manitoba S. M. HARBICHT, W. G. FRANZIN, and K. W. STEWART 47
- Yellow-billed Loon, *Gavia adamsii*, breeding chronology and reproductive success in arctic Alaska MICHAEL R. NORTH and MARK R. RYAN 48
- New distribution records of marine fishes off Washington, British Columbia, and Alaska ALEX E. PEDEN and GLEN S. JAMIESON 49
- The status of Trumpeter Swans, *Cygnus buccinator*, in western Canada, 1985 RICHARD W. MCKELVEY, KEVIN J. MCCORMICK, and LEONARD J. SHANDRUK 49
- New and significant records of Ontario sedges (Cyperaceae) MICHAEL J. OLDHAM and WILLIAM J. CRINS 50
- Observations on the diel and seasonal drift of eggs and larvae of anadromous Rainbow Smelt, *Osmerus mordax*, and Blueback Herring, *Alsea aestivalis*, in a coastal stream on Prince Edward Island C. E. JOHNSTON and J. C. CHEVERIE 50
- Bitterroot, *Lewisia rediviva*, in southwestern Alberta: cultural versus natural dispersal MICHAEL CLAYTON WILSON, LEONARD V. HILLS, BRIAN O. K. REEVES, and STEPHEN A. AABERG 51
- Distribution of the Showy Aster, *Aster conspicuus* AUGUST J. BREITUNG 52
- Notes**
- Evidence of autumnal Harbour Seal, *Phoca vitulina*, movement from Canada to the United States M. ROSENFELD, M. GEORGE, and J. M. TERHUNE 52
- Lesser Snow Geese, *Anser c. caerulescens*, nesting on Jenny Lind Island, Northwest Territories KEVIN J. MCCORMICK and BERT POSTON 53
- The Redfin Shiner, *Notropis umbratilis* in the Middle Thames River, Ontario, and its association with breeding Longear Sunfish, *Lepomis megalotis* D. B. NOLTIE and R. J. E. SMITH 53

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Cover: Hoary Bat, *Lasiurus cinereus* (Newfoundland Museum MA-32), reacting to camera; 15 August 1984; Sycamore Place, St. John's, Newfoundland. Photographed by John E. Maunder. See note pp. 726-728.

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Migration and Winter Populations of Greater Yellowlegs, *Tringa melanoleuca*, in Western Washington

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Buchanan, Joseph B. 1988. Migration and winter populations of Greater Yellowlegs, *Tringa melanoleuca*, in western Washington. *Canadian Field-Naturalist* 102(4): 611-616.

Year-round observations of Greater Yellowlegs, *Tringa melanoleuca*, were made at two estuarine study sites in western Washington, 1980-1983. Spring peaks occurred earlier in the season than those documented in the first half of this century. Individuals occasionally present during summer months retained Basic plumage. Adult fall migrants arrived in early-mid July and juveniles arrived in late August. The winter range of this species seems to have expanded northward along the Pacific coast; small local populations are now to be found in the western parts of Oregon, Washington and British Columbia. Sudden changes in winter populations were attributed to winter movements. Local movement patterns at both study sites were strongly influenced by the tidal cycle; however, seasonal variations were exhibited at one site.

Key Words: Greater Yellowlegs, *Tringa melanoleuca*, migration, winter, Washington.

Unlike its Palaearctic counterpart the Green-shank, *Tringa nebularia*, the Greater Yellowlegs, *T. melanoleuca*, is not well known in terms of breeding biology (Nethersole-Thompson and Nethersole-Thompson 1979; Cramp and Simmons 1983). Like *T. nebularia*, the species has received little attention during non-breeding periods as well (Tree 1979). General information on *T. melanoleuca* behavior is available in accounts by Bent (1927), Palmer (1967), and Johnsgard (1981), and data on migration are found in studies by Storer (1951), Page et al. (1979), Widrig (1979), and Herman and Bulger (1981). Cramp and Simmons (1983) summarized much of the available data.

During the first half of this century, *T. melanoleuca* was described as a spring and fall migrant in the western regions of Oregon, Washington, and British Columbia (Woodcock 1902; Bent 1927; Kitchin 1934; Munro and Cowan 1947). Only Hoffman (1927), Gabrielson and Jewett (1940), and Jewett et al. (1953) mentioned this species as an occasional winter resident west of the Cascade mountains. Results from recent research (Widrig 1979) and Audubon Society Christmas Bird Counts published in *American Birds* indicate that populations of this species now winter locally in this region.

This paper reports on the current status of *T. melanoleuca* in this region and describes migration timing and foraging movement patterns at the northern limit of the species' winter range.

Study Areas and Methods

The study was conducted at two sites in western Washington. The primary site, Eld Inlet (47°02'N; 123° W), is a long, narrow body of water at the southern terminus of the Puget Sound (Figure 1). Forested bluffs rise to 20-70 m from the shores of the inlet. Salt marsh is almost absent; the largest contiguous salt marsh is only 30 m² in area, but it serves as the primary roost for all shorebirds at this site. Semidiurnal tides range from -3.1 to 16.7 feet (-0.9 to 5.1 m). High tides cover all mud flats and some salt marsh. At mean lower low water approximately 600 ha of mud flats and commercial oyster beds are exposed. Observations of *T. melanoleuca* at Eld Inlet were made on 293 days between July 1980 and March 1983. Observations were also made at the Kennedy Creek delta (47°06'N; 123°03'W), a small estuary at the southern end of Totten Inlet 7 km to the northwest). This site has features similar to Eld Inlet with the exception of a much greater area of salt marsh, as described by Brennan et al. (1985).

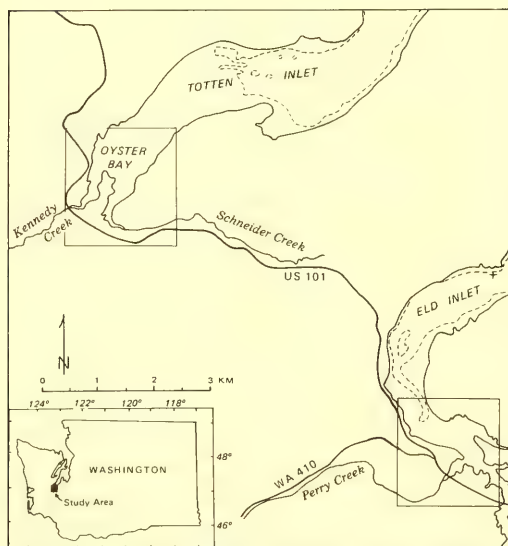


FIGURE 1. Location of the two study areas in western Washington.

The Kennedy Creek delta was visited on 60 days between October 1980 and November 1983.

Observations were made using binoculars or a 15 $\times$ spotting scope. A canoe was used to reach

roost sites during high tides at Eld Inlet. Counts were made during early or late phases of the exposed-mud period when birds were less likely to be widely dispersed or obscured from view. Greater Yellowlegs were aged by criteria provided by Palmer (1967), Burton and McNeil (1976), and Prater et al. (1977).

Results and Discussion

Migration and Seasonal Populations

Year-round migration trends are shown in Figure 2. The earliest fall migrants typically arrived in early to mid-July, although in 1982 birds were present at both Eld Inlet and Kennedy Creek delta in late June. Fall migration was rather protracted and peaked in September in 1981 and 1982 but did not show a distinctive peak until late October in 1980. In 1981 the fall movement was bimodal, with the early peak of adult birds occurring in early August. The first juveniles were observed 26 August 1981 and 27 August 1982, two weeks later than the early arrival date reported by Page et al. (1979). The first signs of molt into Basic-1 plumage were noted during September of each year.

Results from this study are in agreement with earlier reports which stated that autumn migration was concentrated during the months August to October in Oregon (Gabrielson and Jewett 1940),

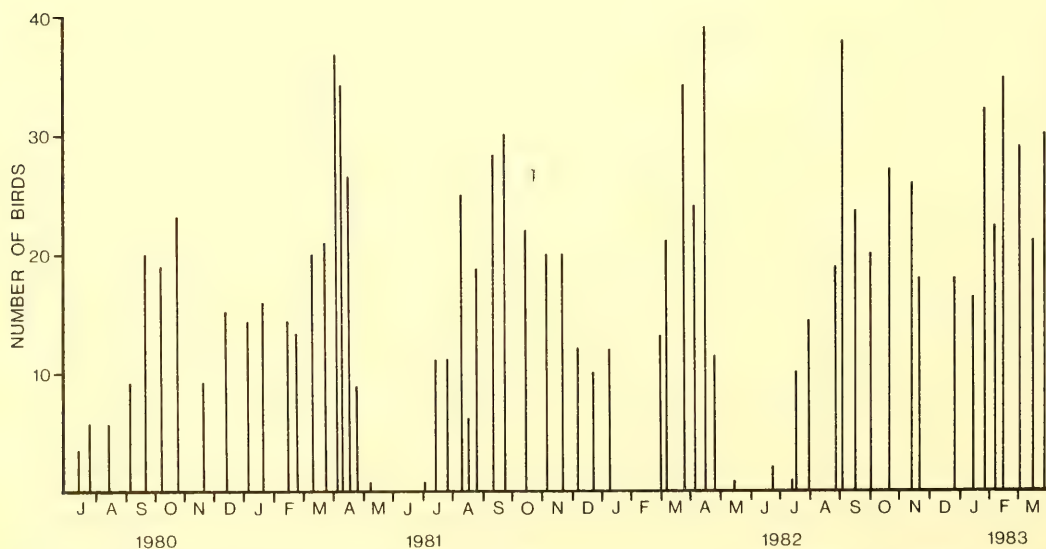


FIGURE 2. Numbers of Greater Yellowlegs at Eld Inlet, 1980–1983. For purposes of clarity, the graph bars represent counts that changed from previous counts, or counts that were unchanged for more than 10 days. The site was not visited during much of January and February 1982.

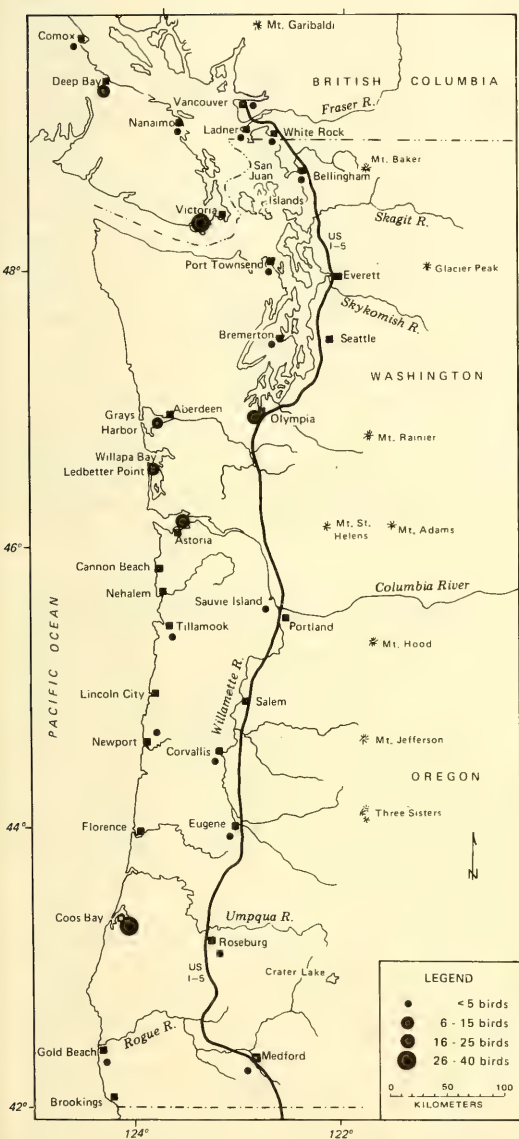


FIGURE 3. Mean numbers of Greater Yellowlegs encountered during Christmas Bird Counts 1970-1982 (data published in *American Birds*) in western British Columbia, Washington and Oregon. Some areas did not have counts every year during this period.

and that inclusive dates for Washington were 4 July to 2 November (Jewett et al. 1953). More recently, Widrig (1979) detected two distinct peaks

during fall migration at Leadbetter Point NWR on the outer coast of Washington. His data reflect the peak movement of adults in July and that of juveniles in mid-September.

Early to mid-winter (November-January) numbers were fairly stable at both Eld Inlet and Kennedy Creek delta, usually between 10 and 20 birds at each site. In late January of 1981 and 1983 temporary population increases were noted at Kennedy and Eld, respectively. The 1983 increase corresponded with the beginning of lower diurnal low tides. Mid-winter movements necessitated by displacement or adverse environmental conditions have been shown for other shorebird species (Atkinson et al. 1981; Symonds et al. 1984; Townshend 1985). Widrig (1979) also noted a temporary mid-winter influx of *T. melanoleuca* at Leadbetter Point. The origin and eventual destination of these birds remain unknown.

That the winter range of this species has been expanding northward was first suggested by Palmer (1967) in regard to Atlantic coast populations. This appears to be true of Pacific coast populations as well. Current winter records summarized from Christmas Bird Count data (published in *American Birds* 1970-1982) are indicated in Figure 3.

The first evidence of spring movement was observed between mid-February and mid-March. At Eld Inlet spring migration peaked in early April in 1981 and in mid-April in 1982. Spring passage was completed soon after the final peak; populations dropped to between five and ten birds within two weeks at each site. The Alternate plumage was first noted in mid-March; on two occasions birds in Basic plumage were observed as late as mid-May.

Inclusive dates for spring migration west of the Cascade mountains in Washington were given as 14 April through 27 May by Jewett et al. (1953). Brown (cf. Jewett et al. 1953), monitoring spring migration in May of 1920 at Grays Harbor, Washington, observed one Greater Yellowlegs on 4 May, three on 9 May, and by 17-24 May concluded that they were abundant. Similarly, early reports of migration by this species on the Atlantic coast show that spring migration typically peaked between late April and mid-May (Nichols and Harper 1916; Stone 1937; Urner and Storer 1949). More recently, however, Widrig (1979) and Herman and Bulger (1981) have found that the peak of spring passage occurred during the second and third weeks in April. Recent studies in South America (Spaans 1978; Myers and Myers 1979) indicate that *T. melanoleuca* typically begins its

northward movement during March and early April. This timing of departure from South America fits well with the peak build-up of numbers in more northerly latitudes later in April (see Cramp and Simmons 1983; Reid et al. 1983). In short, the timing of recent spring migration peaks is earlier in the season than those reported in the first half of this century; whether this is an artifact of sampling effort is unknown.

No birds were seen during summer (June) at either site except for two individuals at Eld in late June 1982. *T. melanoleuca* has been observed in the southern Puget Sound during June by others (J. Bulger, L. Salzer, personal communications). The two birds observed in June 1982 were in Basic plumage and may have spent the summer period south of the breeding area. Widrig (1979) also saw individuals during June at Leadbetter Point NWR.

Movement Patterns

One primary and two secondary roosts were utilized by *T. melanoleuca* at Eld Inlet. The primary roost was a patch of salt marsh 30 m² located at the northeast edge of the study area. Secondary roosts seemed to be used as staging areas before movement to the primary roost when disturbances made the main roost undesirable (the roost was near two residences). Yellowlegs also roosted on a large raft of logs secured to pilings near the mouth of Perry Creek from 20 October 1980 until 5 March 1981 when the logs were removed.

During the winter, diurnal low tides commonly ranged as high as 6.0 to 8.0 feet (1.8 to 2.4 m). At this time, foraging yellowlegs were restricted to a narrow band of mud, usually not exceeding 15 m width, along the edge of the inlet. Yellowlegs commonly moved back and forth along the shore on these strips of exposed mud, and readily flew across the inlet to other foraging areas.

Spring and fall diurnal low tides were typically very low (ca 0.0 feet [0.0 m] or less). In these seasons yellowlegs would forage westward along both shores of the inlet in a pattern similar to that exhibited in winter. At 5.0 foot (1.5 m) or lower tides mud was exposed in shallow areas near the

middle of the inlet. Eventually, commercial oyster beds were exposed by the falling tide. All portions of these low-lying mud flats and oyster beds were utilized; however, yellowlegs generally preferred to forage at or near water's edge or along distributaries or pools.

On a rising tide, yellowlegs returned to roost earlier in the tidal cycle during spring and fall than during winter, although I did not quantify this. On many occasions during winter, birds foraged immediately adjacent to the roost until the rising water forced them up onto the salt marsh. Goss-Custard (1969) similarly found that Redshanks (*T. totanus*) foraged for larger proportions of diurnal periods during winter than in spring.

Two known roosting areas were used by the Kennedy Creek delta population. Both were considered secondary roosts because they were subject to inundation by high tides. A primary roost was not present at this site. When local roosting was not possible, these birds may have traveled up to 30 km to roost (see Brennan et al. 1985).

Unlike the movement pattern at Eld Inlet, which varied only when lower tides opened up new areas to foraging, the patterns at Kennedy Creek delta also varied considerably between seasons (Table 1). During November–March, 74% of the foraging activity was confined to the east shore of the inlet. Many of these visits included a brief stay at a secondary roost on the east shore. During April–October, 67% of the observed movements revolved around the south Kennedy Creek channel near the southern edge of the study area. Several salt marsh islands there served as a secondary roost. A transition between these seasonal habitat utilization patterns seemed to occur in October–November when *T. melanoleuca* used both areas on several occasions. If the observed seasonal patterns were governed by spatial/temporal variations in prey availability or prey selection it is likely that the October–November movements served as “sampling” efforts (Krebs 1978) to determine the relative value of the respective higher tide foraging areas.

Movements between Eld Inlet and the Kennedy Creek delta were not confirmed although in mid-

TABLE 1. Tide flat areas utilized by Greater Yellowlegs during early or late phases of the tidal cycle at Kennedy Creek delta (see Figure 1).

Season	E. shore only	S. channel only	E. shore & S. channel	Partial use of E. shore	N. end delta	No pattern
November–March	20	0	2	3	1	1
April–October	0	12	3	1	0	2

March 1981 an increase of seven birds at Eld coincided with a decrease of eight birds at Kennedy. Also, on 29 July 1983, three birds were observed leaving Kennedy on an overland flight in the direction of Eld Inlet.

Conclusions

The Greater Yellowlegs appears to have extended its winter range northward along the Pacific coast of North America and is now reported more frequently in Oregon, Washington and British Columbia than in the earlier part of this century (Figure 3). The reason for this apparent range expansion is unknown as is how this expansion manifests itself in terms of spatial distribution and local population density. A continued increase in local population levels (especially during winter) might have a noticeable effect on intraspecific aggression, seasonal variations in mean flock size and foraging routines, and winter vagility (and mortality).

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Historical Changes in the Unionid Fauna of the Sydenham River Watershed and Downstream Changes in Shell Morphometrics of Three Common Species

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Mackie, G. L., and Jane M. Topping. 1988. Historical changes in the unionid fauna of the Sydenham River watershed and downstream changes in shell morphometrics of three common species. *Canadian Field-Naturalist* 102(4): 617-626.

Of 33 species (and their forms and subspecies) that have been reported from the Sydenham River drainage in Ontario since 1937, only 13 were found living in 1985. None of the four species which are rare or endangered in Canada (*Simpsonaias ambigua*, *Epioblasma rangiana*, *Villosa fabalis*, *Anodonta imbecillis*) and which were once reported from the study area, were found living in 1985. The diversity of Unionidae tends to increase downstream, but with significant variations. Of three species examined for changes in length/width and length/height ratios with distance downstream, only *Anodonta grandis grandis* appears to obey Ortmann's Law of Stream Distribution (obesity and height of shells increase with distance downstream); *Amblema plicata* and *Lasmigona complanata* show either positive or no correlation between length/width ratios and distance downstream. Multiple linear regressions indicate that the variable, distance downstream, significantly ($P < 0.05$) improves models for shell height in all three species studied; models for shell length and width are marginally ($P < 0.12 > 0.06$) improved by distance downstream.

Key Words: Unionids, Sydenham River, Ontario, *Simpsonaias ambigua*, *Epioblasma rangiana*, *Villosa fabalis*, *Anodonta imbecillis*, Ortmann's Law.

The main objective of the present study was to determine what species of Unionidae presently exist in the Sydenham River, Ontario. The Sydenham River is the richest river in Canada for freshwater mussels (Clarke 1978). Thirty-three species have been recorded from the river and its drainage, with 29 reported by LaRocque and Oughton (1937), 32 by Clarke (1973), and 33 by combining the above lists and synonymies and the records in the National Museums of Canada. Of the 33 species, four were reported by Clarke (1977) as being confined within Canada to the Sydenham River. These four are *Anodonta imbecillis*, *Villosa fabalis*, *Simpsonaias ambigua*, and *Epioblasma rangiana*. All occur farther south in the United States but only *A. imbecillis* is common there (Clarke 1976). *E. rangiana* is very rare throughout its range, and the Sydenham River population, although small, may have been the most extant healthy population in North America (Clarke 1978). In addition, *S. ambigua*, *V. fabalis*, and *E. rangiana* are on the list of threatened and endangered species of Canada (Clarke 1977) and/or the United States (Stansbery 1971; Bogan and Parmalee 1983).

The second objective of the study was to determine if changes in shell morphometry of common species occur with distance downstream.

Relying on the river continuum concept (Vannote et al. 1980), which predicts that erosional substrates and coarse particulate matter of low-order streams are replaced by depositional substrates and fine particulate organic matter in higher-order streams, we hypothesized changes in shell morphometry that would reflect the greater food availability and adaptations to life in soft sediments with increasing distance downstream. The changes hypothesized were those predicted by Ortmann's (1920) "Law of Stream Distribution", which states that generally, when a relatively primitive unionid species is traced downstream (i.e. in the direction in which the gradient and maximum water velocity become progressively less), the obesity of the species increases; that the increase in obesity is commonly and significantly accompanied by an increase in size; and that in several species there is also an increase in the height/length ratio of the shell, leading to sphericity. Although Ortmann's conclusions have been supported by many workers (e.g. Grier 1920; Ball 1922; Baker 1927; Stansbery 1970; Newell and Hidu 1982), other studies modify or even contradict them (Danglade 1914; Horn and Porter 1981; Tevesz and McCall 1982; Kat 1982; Hinch et al. 1986).

The present study examines changes in the length, height, and width of the shell in relation to

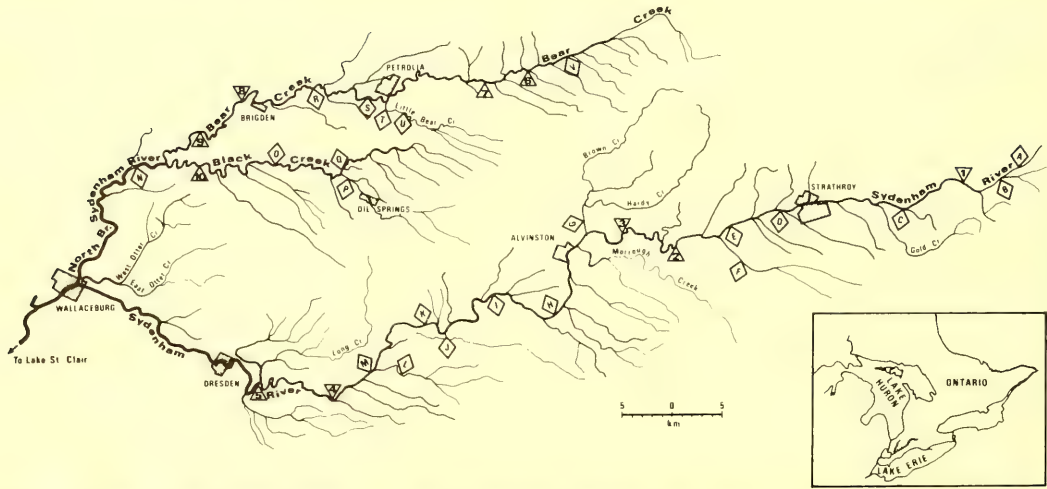


FIGURE 1. Map of study area showing locations of intensive (numbers) and extensive (letters) study stations. Inset shows location of study area between Lake Huron and Lake Erie.

distance downstream for three species, *Amblema p. plicata*, *Anodonta grandis grandis*, and *Lasmigona complanata* in the Sydenham River and its major tributaries. These changes have not been previously examined for any of the three species in a river system, although Grier (1920) and Stansbery (1971) have examined shell morphometrics of *A. p. plicata* in Lake Erie.

Study Area

The Sydenham River watershed is part of the Lake St. Clair drainage (Figure 1). The river is situated in the south-western part of Ontario and lies within the Carolinian Zone. The basin has an overall length of about 100 km, an average breadth of nearly 38 km, and a total drainage area of 2735 sq km (Department of Energy and Resources Management 1965). The main drainage systems are the Sydenham River and the North Sydenham River which receives two large tributaries, Black Creek and Bear Creek (Figure 1). Extensive land

drainage systems (large ditches or canals and dykes) are common around most towns, especially Wallaceburg. The mean temperature dissolved oxygen content and water velocity during May to September at ten stations are given in Table 1.

Materials and Methods

Both extensive and intensive studies were carried out. The extensive study was a survey of the species present at each of 22 stations in the study area (Figure 1, Stations A to V). The stations selected included those studied and reported by Clarke (1973) [i.e. Station A = Station 1040 of Clarke; C = 1041; K = 552], those studied but reported only in his field notes [i.e. Station H = Station 1051 of Clarke; J = 1050; S = 1187], and new stations. The new stations were selected according to their accessibility at approximately 10 km intervals on each of the main rivers and some of their tributaries. Each station was visited once only in August 1985 and usually at least 60

TABLE 1. Some physical and chemical features of the water at the ten intensive study stations.

WATER VARIABLES	STATIONS									
	1	2	3	4	5	6	7	8	9	10
Velocity, cm/sec	2.4	11.1	19.2	2.8	14.3	2.3	5.6	18.3	4.3	<0.5
Temperature, °C	18.2	17.6	18.5	20.7	20.7	21.8	21.0	21.5	17.7	18.4
Dis. Oxygen, mg/L	11.6	9.3	9.2	7.7	7.7	8.3	9.7	9.8	7.2	7.5

person-minutes was spent looking for Unionidae at each station. The kinds and numbers of specimens of each species found was recorded for each station.

The intensive studies included quantitative measurements of unionid densities and water quality measurements at each of ten stations in the study area, as well as qualitative surveys of species present. Each station was visited four times at approximately four-week intervals from 15 May to 1 September 1985. The stations selected (Figure 1, Stations 1 to 10) included those studied and reported by Clarke (1973) [i.e. Station 2 = 1044 of Clarke; 3 = 1045; 4 = 1046; 5 = 1049], those studied but reported only in his field notes [i.e. Station 6 = Station 1188 of Clarke; 8 = 1186], as well as four new stations that were known to contain Unionidae on the basis of exploratory surveys. Stations 1 to 5 were on the main Sydenham River and Stations 6 to 10 were on the main tributaries of the North Sydenham River (Figure 1).

Before sampling the Unionidae at each station, water temperature ($^{\circ}\text{C}$) and dissolved oxygen (mg/L) were measured using a YSI oxygen meter, model 27. Water velocity (cm/sec) was measured with a portable Marsh McBirney water current meter, model 201. All measurements were taken at mid-stream.

Densities of bivalves were estimated using catch per unit effort and mark-recapture methods. Catch per unit effort yielded relative densities, with a unit effort being 60 person-minutes. Although both living specimens and empty shells were collected, mean relative densities were calculated only for living bivalves in the four sampling trips (i.e. $N = 4$ at each station). For each living specimen, the shell was marked (by scratching a number through the periostracum to the calcareous shell) and the shell length (greatest anterior to posterior distance), height (greatest ventral to dorsal umbonal distance), and width (greatest lateral distance) were measured (cm) at the site before returning the specimen to the river. Using the equations employed by fisheries biologists (Young and Robson 1978), the ratio of living specimens collected and the total marked to those recaptured provided an estimate of the density of unionids at each station. Although four species (*A. p. plicata*, *A. g. grandis*, *L. complanata*, *Potamilius alatus*) were marked, only one (*A. p. plicata*) was recaptured and only at two stations. All empty shells were returned to the laboratory where the length, height and width of shells, with both valves still intact, were recorded.

Three species, *A. p. plicata*, *A. g. grandis*, and *L. complanata*, were present in sufficient numbers to

permit statistical analyses of the measurement variables at six or more stations (Table 4). Mean shell length was determined on small sample sizes ($N < 10$) as $L = L(\text{cm})/N$; mean shell lengths for larger samples were determined using the probability paper method (Cassie 1950, 1954) on length-frequency data.

Stepwise linear regressions were performed on length and height and length and width data, and then length/height and length/width ratios were calculated for unionids of "standard length" at each station. The standard length used for *A. p. plicata* was 12 cm, for *A. g. grandis*, 13 cm, and for *L. complanata*, 15 cm. These lengths are close (to the nearest unit) to the means derived above. The length/height and length/width ratios derived for the standard length unionids were then regressed against distance downstream for each species. Rigid statistical tests on these regression data were not performed because heterogeneity of variance commonly occurs when compounding variables into ratios, and there are not satisfactory transformations to correct for it (Steel and Torrie 1980). The analyses are included here only because they allow comparisons with values reported in the literature which, without exception, compounds the morphometric variables into ratios. The sample sizes and the stations used for each species in this analysis are given in Table 4. Regression equations are given only when the slopes differ significantly ($P < 0.05$) from zero.

Since the use of ratios to measure size-independent shape differences are largely invalid and have many unattractive statistical properties (Green 1979, p. 104), multiple linear regressions were performed. A multivariate least squares test was applied to the variables, length, height, width and distance downstream for each of the three species. The test is completely general and allows any linear contrasts on vectors of dependent as well as independent variables. The data were untransformed because plots of the means against the variances for each of the morphometric variables indicated homogeneity of the error variance.

Unionid diversity (d) was estimated on the catch per unit effort data for living and dead unionids using, $d = -\sum n_i / N \log_2 n_i / N$, where n_i = number of individuals in the i th species and N = total number of individuals.

Results

A total of 27 species were collected in the study area. Only 13 of these were found living in the Sydenham River and 12 in the North Sydenham River and its two main tributaries, Black Creek

TABLE 2. Unionidae collected in the "Lake St. Clair Drainage" (LaRoque and Oughton 1937) and in the Sydenham River since 1963–1967. The 1963–1967 data are based on collections of living specimens and empty shells made by H. D. Athearn and Carol B. Stein who deposited records in the National Museum of Natural Sciences, Ottawa. The 1985 data are based on the present study; L = living specimens present; D = only empty shells were found; — = species not found.

SPECIES	Lake St. Clair Drainage 1937	Sydenham River		
		1963–67	Main River 1985	North 1985
Subfamily ANODONTINAE				
<i>Alasmidonta marginata</i> Say, 1818	x	x	D	—
<i>Alasmidonta viridis</i> (Rafinesque, 1820)	x	—	—	D
<i>Anodonta g. grandis</i> Say, 1829	x	x	L	L
<i>Anodonta imbecillis</i> Say, 1829*C	—	x	—	—
<i>Anodontooides ferussacianus</i> (Lea, 1834)	x	x	L	L
<i>Lasmigona complanata</i> (Barnes, 1823)	—	x	L	L
<i>Lasmigona compressa</i> (Lea, 1829)	x	x	D	D
<i>Lasmigona costata</i> (Rafinesque, 1820)	x	x	D	D
<i>Simpsonaias ambigua</i> (Say, 1825)*, *C	—	x	—	—
<i>Strophitus u. undulatus</i> (Say, 1817)	x	x	L	L
Subfamily AMBLEMINAE				
<i>Amblesma p. plicata</i> (Say, 1817)	x	x	L	L
<i>Cyclonaias tuberculata</i> (Rafinesque, 1820)	x	x	L	—
<i>Elliptio dilatata</i> (Rafinesque, 1820)	x	x	D	D
<i>Fusconaia flava</i> (Rafinesque, 1820)	x	x	D	D
<i>Pleurobema sintoxia</i> (Rafinesque, 1820)	x	x	D	D
<i>Quadrula p. pustulosa</i> (Lea, 1831)	x	x	L	L
<i>Quadrula q. quadrula</i> (Rafinesque, 1820)	x	x	L	L
Subfamily LAMPSILINAE				
<i>Actinonaias ligamentina carinata</i> (Barnes, 1823)	x	x	L	L
<i>Epioblasma rangiana</i> (Lea, 1839)*, *C	—	x	D	—
<i>Epioblasma triquetra</i> (Rafinesque, 1820)	x	x	D	—
<i>Lampsilis fasciola</i> (Rafinesque, 1820)	x	x	—	D
<i>Lampsilis ventricosa</i> (Barnes, 1823)	x	x	D	D
<i>Lampsilis radiata</i> f. <i>luteola</i> (Lamarck, 1819)	x	x	L	L
<i>Lampsilis radiata siliquioidea</i> (Barnes, 1823)*B	x	x	L	L
<i>Leptodea fragilis</i> (Rafinesque, 1820)	x	x	L	L
<i>Ligumia recta</i> (Lamarck, 1819)	x	x	D	D
<i>Obliquaria reflexa</i> (Rafinesque, 1820)	x	—	—	—
<i>Obovaria subrotunda</i> (Rafinesque, 1820)	—	x	D	D
<i>Obovaria olivaria</i> (Rafinesque, 1820)	x	—	—	—
<i>Potamilus alatus</i> (Say, 1817) *D	x	x	L	L
<i>Ptychobranchus fasciolaris</i> (Rafinesque, 1820)	x	x	D	D
<i>Truncilla truncata</i> (Rafinesque, 1820)	x	x	L	L
<i>Villosa fabalis</i> (Lea, 1831)***, *C	x	x	—	—
<i>Villosa iris</i> (Lea, 1829)	x	x	—	—

*Species listed by Stansbery (1971) as rare and endangered.

**Species listed by Chambers (1981) as endangered and threatened.

***Species recommended by Jenkinson (1981) for list of endangered and threatened species.

*B *L. radiata siliquioidea* = *L. radiata* f. *luteola*.

*C Species listed by Clarke (1976) as endangered in Canada.

*D *Potamilus alatus* = *Proptera alata*.

and Bear Creek (Table 2). None of the rare, endangered or threatened species (Table 2) were found living in the study area.

The most common species are *A. plicata*, *A. g. grandis*, and *L. complanata*, being well represented at most stations in the study area (Table 3). *P.*

alatus, *Leptodea fragilis*, and to some extent, *Quadrula q. quadrula* and *Lasmigona costata* are common at some stations only.

There are no significant differences ($P > 0.12$) in mean lengths of unionids among stations for any of the three common species studied (Table 4).

TABLE 3. Mean numbers of living Unionidae found per unit effort (= 60 person minutes) at Stations 1 to 10. Complete names for species are given in Table 2.

SPECIES	STATIONS									
	1	2	3	4	5	6	7	8	9	10
<i>A. g. grandis</i>	10	4	4	6	4	3	4	3	2	5
<i>A. ferussacianus</i>	—	—	—	—	—	1	—	—	—	—
<i>L. complanata</i>	—	2	—	1	—	6	1	18	21	9
<i>S. u. undulatus</i>	—	—	—	—	—	—	—	—	1	—
<i>A. p. plicata*</i>	—	15	9	3	2	2	33	1	—	—
<i>C. tuberculata</i>	—	—	—	—	1	—	—	—	—	—
<i>Q. p. pustulosa</i>	—	2	—	—	3	—	—	—	—	—
<i>Q. p. quadrula</i>	—	—	—	—	8	—	—	—	5	1
<i>A. l. carinata</i>	—	—	—	—	2	1	—	—	1	—
<i>L. r. f. luteola</i>	—	2	—	—	—	4	—	—	1	—
<i>L. fragilis</i>	—	3	—	3	—	—	—	3	3	5
<i>P. alatus</i>	—	1	—	6	5	—	—	—	8	2
<i>T. truncata</i>	—	3	2	—	4	—	—	2	3	2

*The mark-recapture method gave estimates of 125 and 550 individuals at Stations 2 and 7, respectively.

Differences in obesity, as reflected in length/width ratios, seem to be present among at least some stations for each species. *A. p. plicata* appears to become narrower downstream (i.e. clams at the most downstream station (K) appear to have larger length/width ratios than those at the

most upstream (2) station, Figure 2), but *A. g. grandis* seems to become more obese with distance downstream (Figure 3). *L. complanata* shows great variation in width downstream, but width is not correlated with distance downstream (Figure 4). Length/height ratios also seem to differ among

TABLE 4. Mean SL (shell lengths) and C.I. (confidence intervals) of three species of Unionidae in the Sydenham River watershed. N = sample size. Locations of stations may be found in Figure 1.

<i>Amblema p. plicata</i>							
	STATIONS						
	E	2	3	I	K	M	4
SL, +/-C.I.	11.6, 3.0	11.1, 1.6	12.0, 2.1	12.3, 1.3	12.2, 1.3	12.1, 1.8	12.6, 1.3
N	9	9	14	15	10	5	4
<i>Anodonata g. grandis</i>							
Sydenham River							
	STATIONS						
	1	2	3	K	4	5	
SL, +/-C.I.	12.3, 2.3	12.5, 2.3	12.6, 3.0	12.4, 2.1	12.8, 3.1	13.3, 2.6	
N	10	7	3	5	3	4	
Bear Creek							
	STATIONS						
	V	6	7	S	8	9	
SL, +/-C.I.	10.3, 1.8	10.2, 3.0	10.2, 4.8	12.0, 4.0	13.0, 3.7	12.1, 3.0	
N	5	3	4	4	11	4	
<i>Lasmigona complanata</i>							
	STATIONS						
	V	6	7	S	R	8	9
SL, +/-C.I.	14.2, 2.2	13.8, 2.1	14.5, 2.0	14.9, 2.5	15.8, 1.1	15.6, 0.9	15.5, 0.8
N	5	9	3	4	4	15	18

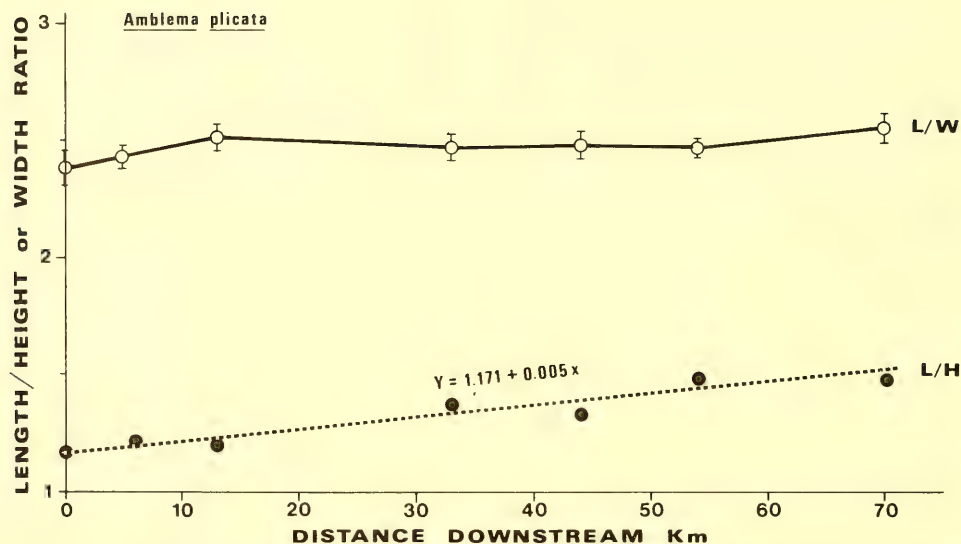


FIGURE 2. Relationship between length/width (L/W) and length/height (L/H) of *Amblema p. plicata* and the distance downstream in the Sydenham River. The stations used are given in Table 4, Station E being 0 and Station 4 being 200 m downstream. Vertical bars are standard errors of the estimated ratio.

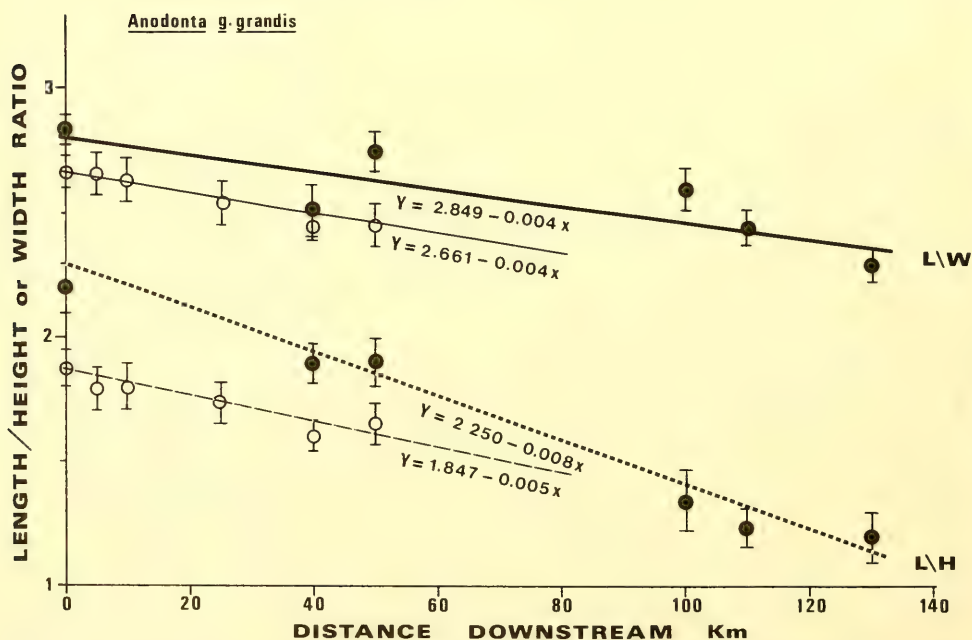


FIGURE 3. Relationship between length/width (L/W) and length/height (L/H) of *Anodonta g. grandis* and the distance downstream in the Sydenham River (solid circles) and Bear Creek (open circles). The stations used are given in Table 4, Station 1 being 0 km downstream. Vertical bars are standard errors of the estimated ratios.

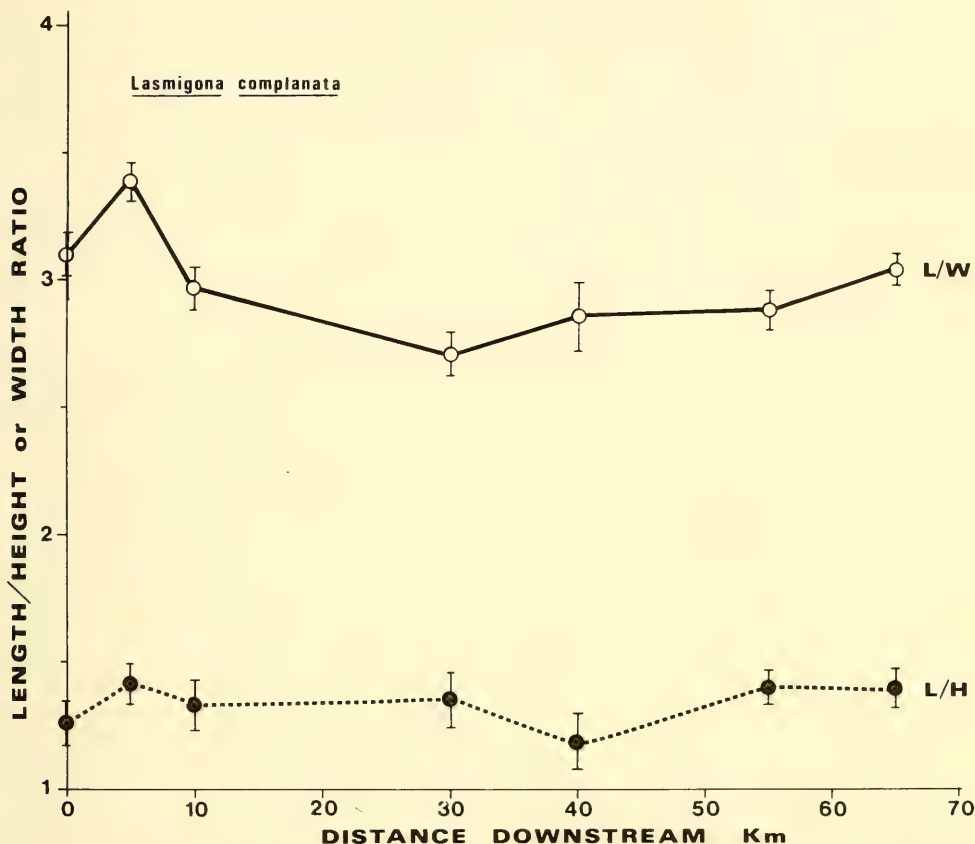


FIGURE 4. Relationship between length/width (L/W) and length/height (L/H) of *Lasmigona complanata* and the distance downstream in Bear Creek. The stations used are given in Table 4, Station V being 0 and Station 9 being 65 km downstream. Vertical bars are standard errors of the estimated ratios.

stations for all species. However, stepwise linear regression of the length/height ratio with distance downstream yields slopes significantly different from zero for only *A. plicata* (Figure 2) and *A. g. grandis* (Figure 3); the length/height ratios of *L. complanata* do not correlate ($P > 0.10$) with distance downstream (Figure 4).

The stepwise multiple linear regressions indicate that distance is not a highly significant variable in the shell length or width models of any of the three species studied (Table 5). Distance downstream is a significant ($P < 0.002$) variable in the height models of both *A. g. grandis* and *A. p. plicata* from the Sydenham River and *L. complanata* from Bear Creek, but marginally significant ($P = 0.053$) in the height model of *A. g. grandis* from Bear Creek; distance downstream only slightly improves (i.e.

$P < 0.11 > 0.06$) the models for length of *A. p. plicata* and the length and width of *L. complanata* (Table 5).

Species diversity of both living specimens and empty shells in the Sydenham River tends to increase for 85 km downstream, reaching a maximum approximately 10 km southwest of Shetland, Ontario (Figure 5). However, significant variations within this 85 km reach are present.

Discussion

The Carolinian zone of southwestern Ontario, one of the five most threatened natural regions in Canada, has about one-third of Canada's endangered, threatened and rare species (World Wildlife Fund Canada 1984). The present study indicates that the four rare or endangered unionid

TABLE 5. Stepwise linear regression models for length (L), width (W) and height (H) of shells of three species of Unionidae in the Lake St. Clair drainage. N = number of specimens used for the models.

Model	Adjusted Multiple R	P (2 tail) for each variable
<i>Anodonta g. grandis</i> — Bear Creek (N = 30)		
$L = 2.50 + 0.44H + 1.39W$	0.916	H, = 0.004; W, < 0.001
$W = -0.44 + 0.41L + 0.01D$	0.896	L, < 0.001; D, = 0.113
$H = -0.39 + 0.58L + 0.02D$	0.846	L, < 0.001; D, = 0.012
<i>Anodonta g. grandis</i> — Sydenham River (N = 28)		
$L = 1.52 + 1.10W + 0.80H$	0.568	W, = 0.003; H, = 0.006
$W = 0.95 + 0.27L$	0.412	L, = 0.003
$H = 2.37 + 0.29L + 0.01D$	0.769	L, < 0.001; D, = 0.002
<i>Amblema p. plicata</i> — Sydenham River (N = 66)		
$L = -0.54 + 0.71H + 1.25W + 0.01D$	0.780	H, W, < 0.001; D, = 0.110
$W = 0.19 + 0.38L$	0.778	L, < 0.001
$H = 2.95 + 0.55L - 0.02D$	0.769	L, < 0.001; D, < 0.001
<i>Lasmigona complanata</i> — Bear Creek (N = 58)		
$L = 1.51 + 0.91H + 0.85W - 0.01D$	0.912	H, W, < 0.001; D, = 0.108
$W = -0.28 - 0.27H + 0.52L + 0.01D$	0.721	H, = 0.015; L, < 0.001; D, = 0.059
$H = 0.16 + 0.78L - 0.38W + 0.01D$	0.876	L, < 0.001; W, = 0.015; D, = 0.002

species (*S. ambigua*, *A. imbecillis*, *V. fabalis* and *E. rangiana*) of Canada either are no longer living in the Sydenham River watershed or are in such small densities that they were not found. Moreover, of nine species restricted to the Lake St. Clair drainage in Canada (*Lampsilis fasciola*, *Obovaria subrotunda*, *Truncilla truncata*, *Obliquaria reflexa*, *Ptychobranchus fasciolaris*, *Alasmidonta viridis*, *Pleurobema sintoxia*, *Cyclonais tuberculata*, and *Quadrula p. pustulosa*) (Clarke 1981), but present elsewhere in the United States, only *T. truncata*, *C. tuberculata*, and *Q. p. pustulosa* were found still living in the Sydenham River watershed. Only *T. truncata* is common; *C. tuberculata* and *Q. p. postulosa* are very rare in the study area. Over the past 50 years, 20 of the 33 species seem to have either disappeared or are represented by empty shells only (Table 2).

While the length/width and length/height ratios appear to vary with distance downstream for some species (e.g. *A. g. grandis*, *A. p. plicata* Figures 2 and 3), the models derived from stepwise multiple linear regressions indicate that distance downstream has only a minor influence on shell obesity of the three species studied. These results do not support entirely Ortmann's (1920) "Law of Stream Distribution" (see introduction). Clearly, there are both inherited (e.g. species differences) and environmental factors (e.g. significant spatial variations) that determine changes in shell

morphometry downstream. That is, the three species studied here each show a different response to distance downstream; for some, the changes in shell morphometry are not unidirectional, and seem to vary according to local environmental conditions. This is especially evident for *A. g. grandis* which shows different length, width and height models in Bear Creek and Sydenham River. The environmental factors have not been identified in this study, but water velocity, substrate type, and size of stream (although all are correlated) have been overwhelmingly implicated by other workers (see Eagar 1978 for a thorough discussion). Indeed, Ortmann (1920) noted that his generalizations did not apply to those species that showed "appreciable specializations". The changes in shell morphometry observed in a single species in two adjacent rivers of the present study suggest that the environment may strongly influence the shell morphometry of several species in the Sydenham River watershed and needs to be investigated further.

The length model for *A. p. plicata* indicates (i.e. $P = 0.11$) increased growth with distance downstream in the Sydenham River. However, Stansbery's (1971) data suggest that reduced growth in length should have occurred; his rationale was that mud substrates (which are characteristic of downstream reaches in the present study) reflect low water-flow regimes and therefore

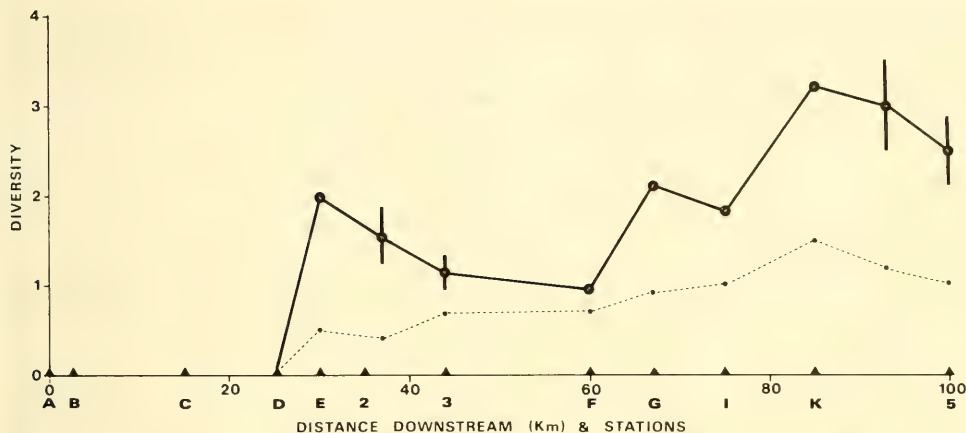


FIGURE 5. Variations in mean species diversity of dead and living Unionidae in the Sydenham River. See Figure 1 for locations of stations. 95% confidence intervals (vertical bars) are calculatable for numerical stations only ($N = 4$); only single estimates are possible for lettered stations.

a reduction in available food may be a cause of reduced growth in *A. p. plicata* in muddy habitats in Lake Erie. The species exhibits greater obesity in Lake Erie than in the Sydenham River, but lake forms of a river species generally have a greater obesity (Stansbery 1961). The essential difference between lake and river varieties of the same species (Eagar 1948) and between lake and river species generally may be regarded as constituting an extension of Ortmann's Law (Eagar 1978).

The great variation in unionid diversity in the Sydenham River is no doubt attributable to changing environmental quality (substrate and water quality). Over the years an extensive agricultural drainage network, consisting of numerous canals and ditches, has been created to drain the predominantly agricultural land in the Sydenham River watershed. Deteriorating water quality with distance downstream is suggested by the diminishing dissolved oxygen values from the upstream to downstream stations in Table 1.

Acknowledgments

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National Museums of Canada, NMC numbers 92763 to 92789, inclusive (including subspecies). The authors are also grateful for the referee's comments, especially for the nomenclatorial comments (see footnotes *B and *D in Table 2).

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Recent Increases in the Breeding Population of Ring-billed Gulls, *Larus delawarensis*, in Atlantic Canada

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Lock, A. R. 1988. Recent increases in the breeding population of Ring-billed Gulls, *Larus delawarensis*, in Atlantic Canada. *Canadian Field-Naturalist* 102(4): 627-633.

Recent censuses of Ring-billed Gulls (*Larus delawarensis*) in Atlantic Canada suggest breeding populations of 1700 pairs in the Maritime provinces, 800 pairs in Labrador, and in excess of 5300 pairs in insular Newfoundland (including St. Pierre and Miquelon). The population history of this species in each of these areas indicates mean annual population growth rates of 21% for the Maritimes and between 12% and 21% for Newfoundland. The isolated population in Labrador appears to be growing at a lesser rate but there are insufficient population data to quantify these changes.

Key Words: Ring-billed Gull, *Larus delawarensis*, population, increase, Atlantic Canada.

The traditional breeding range of the Ring-billed Gull, *Larus delawarensis*, extended from the prairies of Canada and the northern United States to the Great Lakes with smaller populations in James Bay, southern Labrador, insular Newfoundland and on the north shore of the Gulf of St. Lawrence. In historic times its numbers seem to have been much reduced by human persecution (Bent 1921), but under protection afforded by the Migratory Birds Convention Act (1917) numbers increased slowly.

The remnant population in the Great Lakes increased to around 20 000 pairs by 1940 (Ludwig 1966) but began a more rapid expansion around 1960. Between 1960 and 1967 the numbers breeding in Lakes Michigan and Huron increased from 27 000 pairs to 141 000 pairs (Ludwig 1974). The Great Lakes population continued to increase by an average of 7.9% per year between 1967 and 1976 and by some 11% per year between 1976 and 1984 (Blokpoel and Tessier 1986). As the population expansion continued, Ring-billed Gulls colonized the St. Lawrence River. They were found breeding there first in 1953, and about 40 000 pairs were counted between Montreal and Quebec between 1979 and 1983 (Mousseau 1984).

By 1965 Ring-billed Gulls had spread to the southern part of the Gulf of the St. Lawrence; at this time they began breeding at Bathurst Harbour in northern New Brunswick [H. Chiasson, Maritime Nest Records Scheme (MNRS)]. Although gulls in Atlantic Canada have been surveyed less intensively than those in central Canada, a series of colony surveys carried out in the Maritime Provinces and Labrador by the Canadian Wildlife Service and in insular

Newfoundland by investigators associated with Memorial University allowed an examination of the increase of the species in the Atlantic region.

Methods

Colonies of Ring-billed Gulls were found by low-level aerial searches of the coasts of Labrador in 1978, of Prince Edward Island in 1986, and of New Brunswick in 1973 and 1986. These searches were carried out from high-winged aircraft (Cessna 172, 180, 185) flying at an altitude of 75 m at 140 to 180 km/hr approximately 50 m offshore. All possible coastal breeding places were carefully examined.

Ring-billed Gull colonies can be identified from the air by the fact that their nests are more closely and regularly spaced than those of Herring Gulls, *Larus argentatus*, with which they are most likely to be confused. They also differ from Herring Gulls in that they are less easily flushed from the nest by the aircraft. In a mixed colony, Herring and Great Black-backed gulls, *L. marinus*, will flush early, leaving a nucleus of closely spaced Ring-billed Gull nests attended by adults. Any such identification made from the air is tentative and a subsequent ground census is needed to provide acceptable evidence of breeding.

Results

Recent Population History in the Maritime Provinces

All known Ring-billed Gull colonies in the Maritime Provinces are listed in Table 1 and their locations are shown in Figure 1. This species was first discovered breeding in the Maritime Provinces on a dredge-spoil island in Bathurst

TABLE 1. Colonies of Ring-billed Gulls in New Brunswick and Prince Edward Island in 1983 and 1986. Colony numbers refer to Figure 1.

Colony		1983		1986	
		Date	Number of nests	Date	Number of nests
NEW BRUNSWICK					
1. Dalhousie Pulp Mill	48°04' N 66°22' W	—	Unknown	10 June	629
2. Belledune Smelter	47°55' N 65°54' W	—	Unknown	10 June	260
3. Bathurst Harbour	47°38' N 65°38' W	3 June	406	11 June	231
4. Tracadie Bar	47°32' N 64°51' W	11 June	60 ¹	18 June	115
5. Tabusintac Bar	47°19' N 64°56' W	13 June	158	23 June	0
6. Neguac Bar	47°15' N 65°00' W	14 June	3	24 June	199
PRINCE EDWARD ISLAND					
7. Cascumpec Bar	46°47' N 64°02' W	17 June	159 ²	5 June	0
8. Indian Point Sandhill	46°37' N 64°18' W	17 June	53	3 June	116
9. Murray Harbour	46°01' N 62°29' W	—	Unknown	27 May	114

¹60 occupied nests and 214 empty nests were counted.

²G. MacDougall, personal communication.

Harbour in northern New Brunswick; nine nests were counted there in 1965 (H. Chiasson, MNRS). The growth of that colony was rapid, if irregular, to the 406 active nests counted there in 1983. In 1972 it was still the only Ring-billed Gull colony known in the Maritime provinces, but the Belledune Point colony, on a reclaimed slag dump at the Brunswick Mining and Smelting Corporation's smelter, was probably founded about that time. In 1976, 86 Ring-billed Gull nests were counted there in a Herring Gull, Great Black-backed Gull and Common Tern, *Sterna hirundo*, colony (P. Maloney, BMSC, personal communication). This colony was not re-examined until 1986, when 260 active Ring-billed Gull nests were counted there.

The Dalhousie colony, on a bark tip at the New Brunswick International Paper mill, was founded in 1982, soon after the company stopped dumping bark at that site (D. Maloney, NBIP, personal communication). It grew rapidly to the 629 active

nests counted in 1986. The dates of foundation of the colonies on Tracadie, Tabusintac and Neguac sandbars are not known, but they were not present in 1973 when I carried out an aerial inventory of bird colonies on that coast. They are subject to disturbance and occasional eggging; consequently, their sizes and positions vary from year to year.

In 1974 a single Ring-billed Gull nest was found in a Herring and Great Black-backed gull colony on Sable Point Island, Murray Harbour, Prince Edward Island. In the following year five nests were counted there (G. Hogan, MNRS), but this colony was not resurveyed until 1986 when 114 active nests were counted. Another colony, apparently founded more recently, was reported on Indian Point Sandhills, Prince Edward Island, by G. MacDougall in 1981 (MNRS). At that time there were 32 nests in a mixed colony with both species of large gulls and Common Terns. That colony grew to 75 nests by 1984 (G. MacDougall, MNRS) and to 116 nests by 1986. In June 1983 a

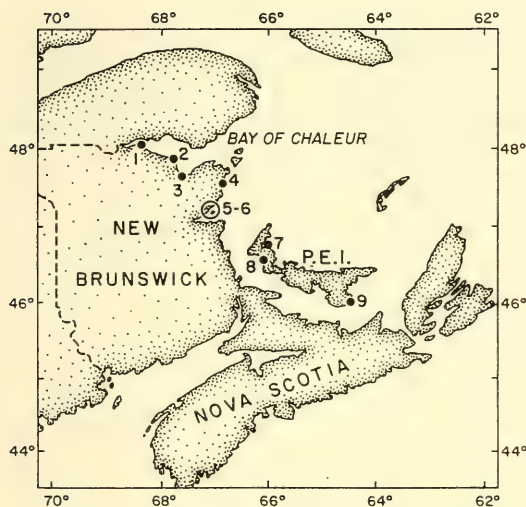


FIGURE 1. Ring-billed Gull colonies in New Brunswick and Prince Edward Island. Colony numbers refer to Table 1.

new P.E.I. colony was discovered on Cascumpec Sandhills but it had disappeared by 1986.

As late as 1972 the only known colony of Ring-billed Gulls in the Maritimes was that in Bathurst Harbour, which then had 119 nests (P. Pearce, MNRS). Since then, the Maritime provinces' breeding population has increased to almost 1700 pairs, a mean annual increase of close to 21%.

Population History — Labrador

The earliest record of Ring-billed Gulls breeding in Newfoundland Labrador was Macoun's (1900) statement, on the authority of A. P. Low, that they bred in the vicinity of Hamilton Inlet. Townsend and Allen (1907) also listed Ring-billed Gulls as a breeding species, referring to Low, though in their own brief visit to the coast they did not see them. Austin (1932) questioned Low's identification of these gulls and he did not list them as breeding in Labrador. The present breeding of Ring-billed Gulls in Labrador only around Hamilton Inlet suggests that Low's early record was probably correct.

The first modern reference to breeding Ring-bills in Labrador was L. M. Tuck's report (*in* Todd 1963) of their breeding in Lake Melville. No specific location was given. The first specific colony record was a 1970 report to the Newfoundland Nest Record scheme (NNRS) by D. Gillespie, which listed 90-100 nests on Bear Island in Lake Melville (54°00'N, 58°53'W). The colonies listed in Table 2 were discovered during the aerial inspection of the Labrador coast in 1978 and they were counted in 1979 and 1980. No gulls bred on Bear Island at that time and the gulls on an islet close to it were identified as Herring Gulls. The few historical data on the breeding of Ring-billed Gulls in Labrador leave it uncertain whether the population is stable or increasing; however, it is likely that, had Ring-billed Gulls been as abundant as they are now, previous investigators would have become aware of their presence.

TABLE 2. Colonies of Ring-billed Gulls in Labrador in 1979 and 1980. Colony numbers refer to Figure 2.

Colony		Date	Number of Breeding Pairs
10. Island in the Backway	54°06' N 58°13' W	9 July 1979	32
11. Island off Eskimo Island	54°00' N 58°36' W	7 July 1979	9
12. Gull Island	54°00' N 58°43' W	7 July 1979	302
13. Island off Burnt Head	53°59' N 58°55' W	7 July 1979	16
14. Island east of St. John Island	53°56' N 58°52' W	6 July 1979	12
15. Green Island	53°55' N 58°59' W	6 July 1979	309
16. Tern Island	53°41' N 56°34' W	6 July 1980	137

TABLE 3. Ring-billed Gull colonies in insular Newfoundland. Colony numbers refer to Figure 2.

Colony		Date	No. of Breeding Pairs
17. Tin Pot Island	50°03' N 56°05' W	1973	100
18. Ladle Island	49°29' N 54°03' W	1986	1400
19. North Penguin Island	49°27' N 53°49' W	1986	750
20. Bellevue Island	47°38' N 53°45' W	1983	present
21. Kelly's Island	47°33' N 53°01' W	1984	200
22. Red Island	47°23' N 54°10' W	1972	present
23. Vicuna Island	47°52' N 54°11' W	1982	200
24. Woody Island	47°13' N 55°02' W	1975	518
25. Spanish Room Point	47°11' N 55°05' W	1984	800
26. Saul Island	47°08' N 55°04' W	1975	probable
27. Duck Island	46°51' N 55°47' W	1975	200
28. Morgan's Island	46°51' N 55°49' W	1978	45
29. Little Green Island	46°51' N 55°50' W	1978	60
30. St. Pierre and Miquelon	—	1983	796
31. Great Garnish Barasway	47°12' N 55°25' W	1985	50
32. Flat Island	48°27' N 58°31' W	1985	100
33. Steering Island	49°56' N 57°50' W	1986	6
34. Whale Islands	50°53' N 57°09' W	1974	75

Population History — Insular Newfoundland

Most of the Atlantic Provinces' Ring-billed Gull population breeds in insular Newfoundland, but the colonies there have not been surveyed repeatedly and it is not possible to deduce their rates of increase accurately. Peters and Burleigh (1951) knew of their breeding only on South Penguin Island (eight nests in July 1945) but

suspected breeding also in St. John's Bay on the northwestern coast. By 1950 a colony had been founded on Browsey Island in a lake on the Avalon Peninsula; this colony grew to 420 nests in 1952 and to 1030 in 1958 (L. M. Tuck, *unpublished*). This colony was abandoned in 1961 when falling water levels connected the island to the mainland. At present 16 colonies are

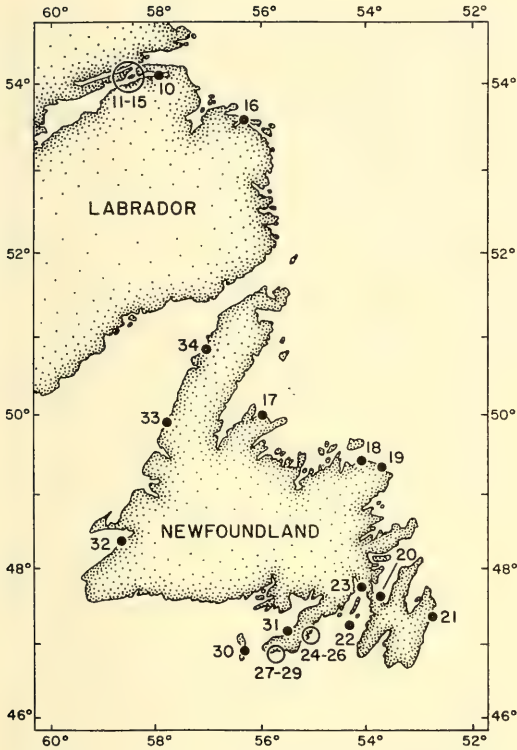


FIGURE 2. Ring-billed Gull colonies in Newfoundland and Labrador. Colony numbers refer to Tables 2 and 3.

known to have been occupied in the last decade (Cairns et al. 1986) [Table 3, Figure 2]. Rather more than 4500 nests have been found in those colonies that have been surveyed and it is a reasonable assumption that the present breeding population is in excess of 5000 pairs.

In 1971 on Miquelon, France, Michel Borotra counted 170 nests in a single colony (Desbrosse et al. 1984). By 1974 three colonies were known on both St. Pierre and Miquelon with a total of 822 pairs. Predation by humans, dogs and foxes kept breeding success low for many years but the population seems to have remained stable: in 1983, 796 nests were counted in the three colonies.

If one assumes that the population of insular Newfoundland (including St. Pierre and Miquelon) was between 50 and 100 breeding pairs in 1945 during Peters and Burleigh's investigations, an increase to 5300 pairs over 40 years requires a mean annual growth rate between 10.4% and 12.4%. That is similar to the growth rate of the Great Lakes population since 1976.

Discussion

Changes in breeding populations of North Atlantic seabirds in recent decades have been the subject of much descriptive and speculative literature. Most observed changes have been ascribable to the influence of man — either directly as a predator or indirectly through commercial and domestic activities. Legal protection and changes in socio-economic patterns and values have relieved coastal species such as gulls and cormorants from direct predation, and their large clutch sizes and low natural mortality rates have allowed their populations to increase quickly.

Ludwig (1966, 1974) monitored Ring-billed Gull populations on the Great Lakes from 1960 to 1965 and observed annual rates of population increase averaging 30%. Their breeding success averaged 1.74 fledglings per breeding pair, and he estimated from band recovery data that mean pre-breeding and adult mortalities were 60% and 12%, respectively. These parameters allowed a population growth of 22.8% annually, close to that observed in the region at that period; this suggests that population growth in the Great Lakes did not rely heavily on immigration.

The rapid increase of the Great Lakes population probably resulted from a simultaneous increase in abundance of the Alewife, *Alosa pseudoharengus*, which provided food, and a drop in water levels, which formed new islands as breeding places (Ludwig 1966; Smith 1968). But their subsequent increase and spread away from the Great Lakes must have had other bases. The most notable increases have occurred in areas of dense human population; adjacent areas which are less developed and less populous have not supported population expansions.

Along the north shore of the Gulf of St. Lawrence, for instance, Ring-billed Gull numbers have not increased in recent decades. In 1940, 1769 pairs were counted in the 10 seabird sanctuaries on that shore, though numbers had been below 200 pairs before that time. The total number of Ring-billed Gulls breeding in that region is not well estimated by these censuses because colonies have moved in and out of the restricted census areas. In 1977 the population in the sanctuaries was 859 pairs (Chapdelaine 1980; that paper included references to all previous censuses). But censuses of all known colonies on the north shore of the Gulf of St. Lawrence between 1976 and 1978 located 1672 pairs, a number comparable to Lewis' 1940 total (G. Chapdelaine, personal communication).

Data to quantify population change in Newfoundland and Labrador do not exist. It is probable that Peters and Burleigh (1951) did not

know all the colonies in existence in Newfoundland at that time, and Table 3, the list of colonies known at present, is probably not complete either. However, it is apparent that Newfoundland Ring-billed Gulls have increased, though probably not as rapidly as those breeding in the Maritime provinces. Data for Labrador are even less conclusive than those for Newfoundland. Because the larger increases in Ring-billed Gull numbers have occurred in regions of greater agricultural and industrial development, we may expect that the Labrador population, like that on the Gulf of the St. Lawrence north shore, has not grown much in the last few decades.

Their initial expansion south of Quebec was in the Bay of Chaleur, and of the 1664 breeding pairs counted in the Maritimes in 1986, more than 1120 pairs (67%) were in three colonies near the towns of Bathurst and Dalhousie. In this area, with a shortage of vacant, natural breeding sites, they are nesting in artificial habitat (on a bark tip, a slag heap and dredge spoil islands), but they do not appear to be feeding primarily on urban wastes. Some of these birds forage at dumps but most were observed foraging in ploughed fields and along the shore. Their further expansion southward has been into areas of lower human population density: on the barrier beaches of northern New Brunswick and in rural areas of Prince Edward Island.

Ring-billed Gulls are smaller than Herring Gulls and Great Black-backed Gulls, but have the same bodily proportions. Their smaller mass and reduced wing-loading give them far more manoeuvrability than the larger gulls. They have also shown a behavioural flexibility which, taken in conjunction with their size, allows them to breed and to exploit food sources in complex human environments more effectively than their larger congeners.

The most notable increases in Ring-billed Gull numbers have occurred in urbanized areas, but studies of the diets of Ring-billed Gulls at some locations in Canada have shown that even in urban areas their diet is primarily of natural origin with fish, insects and earthworms being the most frequent dietary items. Although at Ile de la Cuvée, Montreal, garbage made up 28% of the diet of chicks (Lagrenade and Mousseau 1981), at Toronto Eastern Headland garbage constituted less than 4% of chicks' diet (Haymes and Blokpoel 1978). At breeding sites away from urban centres garbage has been shown to be of lesser importance.

No studies of the diet of Ring-billed Gulls have been done in Atlantic Canada but the pattern of their expansion in the region and their observed

foraging distribution suggest that they are primarily exploiting natural food sources while gaining some benefits from agricultural practices.

The rapid growth of the Maritimes' population requires explanation. It is explicable, in the absence of immigration, only by assuming unusually high reproductive success rates, similar to those calculated by Ludwig (1966) for birds in the Great Lakes. It is more likely that the rapid expansion of the Maritimes' population is fueled by immigration of birds from the St. Lawrence estuary and that the more slowly growing populations in Newfoundland and Labrador have not received extensive immigration. No studies of the reproductive success of Ring-billed Gulls breeding in Atlantic Canada have been carried out.

On the basis of available evidence, there is reason to believe that Ring-billed Gull populations will continue to increase in Atlantic Canada. If the breeding population of the Maritime provinces and insular Newfoundland, estimated conservatively at 7000 pairs in 1986, continued to increase at their present rates, the breeding population by the year 2000 would be over 50 000 pairs. However, it is reasonable to expect that, as in the Great Lakes, the rate of growth will slow as the population increases and limiting factors become operable. It is also to be expected that some of the problems caused by burgeoning Ring-billed Gull numbers in Ontario and Quebec (Blokpoel and Tessier 1986) may, in future, be repeated in the Atlantic Provinces.

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Tree Density and Modes of Tree Recruitment in a Michigan Pine-Hardwood Forest after Clear-cutting and Burning

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Changes in stem density and the relative amount of recruitment by both vegetative reproduction and seedling establishment were assessed over a five-year period following clear-cutting and burning of slash in northern lower Michigan. Prior to disturbance the community consisted primarily of a mixture of *Quercus rubra*, *Populus grandidentata*, and *Pinus strobus*. Following disturbance *P. grandidentata* and *Acer rubrum* comprised 66% and 25%, respectively, of all stems. Stem density declined by 41% in the first five years following fire. There was no change in the relative number of stems of each species during those five years. Animal- and wind-dispersed species had different rates of recruitment by seed. *Populus grandidentata*, *Populus tremuloides*, and *Acer rubrum* were recruited exclusively by vegetative means. *Quercus rubra*, *Amelanchier arborea*, and *Betula papyrifera* were recruited both vegetatively and by seed. *Prunus pensylvanica* was recruited only by seed. No recruitment of *Pinus strobus* and *P. resinosa* occurred in the first four years following disturbance and any future recruitment would have to be from seed.

Key Words: fire, forest succession, Michigan, mortality, recruitment.

Succession may be defined as a process of differential recruitment and mortality among species in a community. Long-term patterns of community composition may be determined within the first few years of a successional sequence based on the species which are the first to arrive at a site (Egler 1954; Christensen and Peet 1981). Different types of disturbance will create different starting conditions and may result in different initial species assemblages (Shirley 1932; Henry and Swan 1974; Oliver and Stephens 1977). The relative amounts of recruitment by stump sprouts, root suckers, and seeds may also be affected by the disturbance regime.

Our objective was to determine patterns of recruitment, mortality, and change in community composition during the initial stage of secondary succession in a pine-hardwood forest. We observed the change in the composition of the tree species following clear-cutting and burning, we measured change in stem density for the first five years after disturbance, and we determined recruitment and mortality for the first four years. By mapping individual stems we were able to assess the relative importance of vegetative reproduction versus seedling establishment. Few studies have measured early stem turnover rates for woody species following disturbance. Most such measures have

been done on older age classes only. Thus, our study provides important information on short-term patterns of tree demography which, in turn, set the stage for long-term changes in species composition.

Methods

The study was conducted on a flat, upland area at the University of Michigan Biological Station in northern lower Michigan (45°34'N, 84°42'W; 237 m elevation). Mean annual precipitation is about 800 mm, distributed evenly throughout the year. The frost-free period averages about 90 days (Anonymous 1971). The soil is a sandy, mixed frigid Entic Haplorthod (Placic Ferro-Humic Podzol) of the Rubicon series, derived from glacial outwash (Unpublished United States Department of Agriculture — Soil Conservation Service Map 1976; Grayling, Michigan). The area supports a second-growth pine-hardwood stand which originated following logging in the late nineteenth century and a wildfire in 1911. The successional trend in this area is from predominantly *Populus grandidentata* Michx. (Bigtooth Aspen) to *Pinus strobus* L. (Eastern White Pine), *P. resinosa* Alt. (Red Pine), *Quercus rubra* L. (Red Oak), and *Acer rubrum* L. (Red Maple) [Cooper 1981]. Within the study area, a site measuring 120 m × 100 m was

TABLE 1. Change in tree composition following clear-cutting and burning. The predisturbance stem density and basal area (BA) were determined by sampling all stumps on the site after cutting but before burning. Mean (SE) stem density after disturbance was determined by sampling four 20 × 20 m quadrats in 1980 and sixteen 10 × 10 m quadrats in 1981–1985. Frequency (FR) was based on occurrence in 100 1 × 1 m quadrats and includes all size classes.

Species	YEAR OF SAMPLE								
	1979			1980			1981		
	Pre-cut Pre-burn			SITE CONDITION Post-cut Pre-burn			Post-cut Post-burn		
	stems per ha	%	BA (m ² /ha)	stems per ha	%		stems per ha	%	FR
<i>Acer rubrum</i>	273 ¹	23	1.38	6650 (1550)	36		9281 (1341)	25	2
<i>Amelanchier arborea</i>	— ¹	—	—	900 (204)	5		94 (49)	0.3	3
<i>Betula papyrifera</i>	43	4	0.63	2813 (2150)	15		569 (367)	2	2
<i>Pinus resinosa</i>	69	6	0.87	0	0		0	0	0
<i>Pinus strobus</i>	169	15	1.43	0	0		0	0	P ²
<i>Populus grandidentata</i>	378 ³	32	7.52	2113 (274)	11		24481 (3026)	66	61
<i>Populus tremuloides</i>	— ³	—	—	0	0		269 (150)	0.7	P
<i>Prunus pensylvanica</i>	0	0	0	0	0		44 (26)	0.1	1
<i>Quercus rubra</i>	233	20	7.34	4763 (963)	26		2269 (535)	6	1

Species	YEAR OF SAMPLE											
	1982			1983			1984			1985		
	SITE CONDITION Post-cut, Post-burn											
	stems per ha	%	FR	stems per ha	%	FR	stems per ha	%	FR	stems per ha	%	FR
<i>Acer rubrum</i>	8488 (1133)	27	2	7006 (885)	26	2	4956 (617)	22	2	5756 (907)	27	4
<i>Amelanchier arborea</i>	69 (28)	0.2	P	100 (52)	0.4	P	81 (36)	0.4	2	63 (32)	0.3	P
<i>Betula papyrifera</i>	175 (113)	0.5	1	94 (52)	0.3	P	75 (46)	0.3	P	119 (48)	0.6	P
<i>Pinus resinosa</i>	0	0	0	0	0	0	0	0	0	0	0	0
<i>Pinus strobus</i>	0	0	P	0	0	P	0	0	P	0	0	P
<i>Populus grandidentata</i>	20256 (2400)	64	64	17613 (1916)	65	51	16294 (1617)	71	62	14294 (1416)	67	52
<i>Populus tremuloides</i>	313 (200)	1	6	244 (144)	1	3	144 (98)	0.6	P	125 (94)	0.6	P
<i>Prunus pensylvanica</i>	38 (18)	0.1	4	31 (22)	0.1	2	50 (20)	0.2	P	31 (15)	0.1	2
<i>Quercus rubra</i>	2519 (579)	8	4	1925 (450)	7	5	1331 (308)	6	4	1063 (260)	5	5

¹*Amelanchier arborea* may have been mis-identified as *Acer rubrum*.
²Present but not in quadrats.
³*Populus tremuloides* may have been mis-identified as *Populus grandidentata*.

TABLE 2. Survivorship and recruitment of stems of trees species in the 1980 burn site for the first three years following fire. Standard errors based on binomial probabilities. Recruitment is mean (SE) of four 10×10 m quadrats.

Species	% of 1981 stems surviving to 1984	% of 1984 stems recruited since 1981	Recruitment since 1981 (stems/ha)
<i>Acer rubrum</i>	42 (3)	0	0
<i>Amelanchier arborea</i>	83 (15)	38 (17)	75 (24)
<i>Betula papyrifera</i>	75 (22)	25 (22)	25 (13)
<i>Populus grandidentata</i>	66 (2)	7 (1)	1075 (185)
<i>Populus tremuloides</i>	38 (10)	0	0
<i>Prunus pensylvanica</i>	50 (35)	67 (27)	50 (14)
<i>Quercus rubra</i>	30 (3)	9 (4)	125 (31)

clear-cut in the fall of 1979 and the early spring of 1980. The site was chosen because it was adjacent to a set of older experimental burn sites that border it on two sides (Scheiner 1983). It was placed there so that data from this site could be compared with that from the older sites. After the logs were removed, the slash was piled to dry. The site was burned on 19 August 1980. The fire was patchy and approximately 15% of the site remained unburned. For additional description of the environment, vegetation, and successional trends see Scheiner and Teeri (1981, 1986), Cooper (1981), and Scheiner (1983; *in press*).

The composition of the trees on the site prior to disturbance was determined by inventorying all stumps after cutting. The diameters of stumps were measured with calipers at cut height, generally about 3 dm above ground level. Conversion to diameter at breast height (dbh) was done by measuring dbh of some individuals which had not yet been cut and stump diameters of those same individuals after cutting. Some small stems of *Amelanchier arborea* (Michx. f.) Fern. (Serviceberry) and *Fagus grandifolia* Ehrh. (Beech) may have been mis-identified as Red Maple and stems of *Populus tremuloides* Michx. (Trembling Aspen) may have been identified as Bigtooth Aspen, but the mis-identified species were rare. Some small Eastern White Pine, Red Maple, and Beech stumps may have been hidden under brush piles and missed.

A set of permanent quadrats was established after the cut in 1980 in order to follow recruitment and survival. The site was divided into four quarters and a 20×20 m plot randomly located within each quarter, allowing for a 10 m wide buffer strip around the edge of the site. Each plot was further divided into four 10×10 m quadrats. All above-ground stems were counted in all 16 of the 10×10 quadrats prior to the fire in July 1980

and in the summers of 1981–1985. Survivorship through the fire was determined by mapping all above-ground stems in two 10×10 m quadrats in different quarters in July 1980. Survivorship and recruitment from July 1981 to July 1984 was determined by mapping stems in four 10×10 quadrats in different quarters. Two quadrats were those mapped in 1980. In addition, 100 1×1 m quadrats were sampled in 1981–1985 for frequency measurements. Frequency is expressed as the percentage of quadrats in which a species appeared. The quadrats were arranged on a grid of five lines, five metres apart, 20 quadrats per line, placed every three metres; a different, randomly placed starting point for the grid was used each year, resulting in grid placement across the middle of the site. This technique followed that used in previous frequency sampling of the experimental burn sites (Scheiner and Teeri 1981).

Results

Prior to cutting, the site was dominated by Bigtooth Aspen, Red Maple, and Red Oak (Table 1). Eastern White Pine was moderately abundant. In the summer following cutting (1980), vigorous stump sprouting by Red Maple, Red Oak, and *Betula papyrifera* Marsh. (Paper Birch) coupled with moderate root suckering in aspen, resulted in a shift in the most abundant species as measured by stem density. The pines remaining on the site consisted of small individuals not removed in the logging process.

The fire burned ca. 85% of the site and killed all remaining stems in the study quadrats. Ten months after fire during the following summer (1981) Bigtooth Aspen was by far the most abundant tree species having sprouted vigorously from root suckers as did Trembling Aspen (Table 1). Red Maple increased in number of stump sprouts and *Prunus pensylvanica* L. (Pin Cherry) appeared on

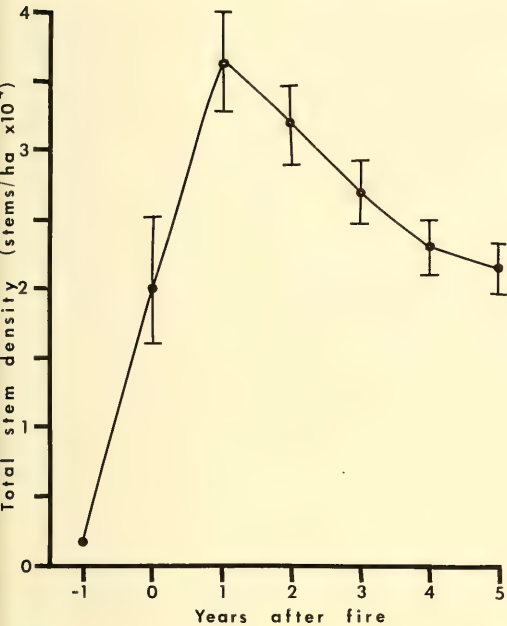


FIGURE 1. Total stem density prior to clear-cutting (yr -1), following clear-cutting but prior to the fire (yr 0 = 1980), and for the first five years (yrs 1-5) after fire. Bars equal one S. E.

the site. The other species were negatively affected by the fire. Red Oak and Paper Birch stumps resprouted at 48% and 20%, respectively, of their pre-fire sprouting densities. Most of the Serviceberry stems were completely killed and both Eastern White Pine and Red Pine were completely eliminated from the study plots. A few small individuals of Eastern White Pine survived outside the plots in patches bypassed by the fire.

In the subsequent four years (1982-1985) there was little change in the relative densities of the species (Table 1), although total stem density decreased by 41% (Figure 1). Only Serviceberry and Paper Birch had high survivorship and they accounted for a small percentage of total stems (Table 2). The species with the highest stem recruitment rates were Pin Cherry, Serviceberry, and Paper Birch (Table 2).

Genets of Red Maple, Serviceberry, Paper Birch, and Red Oak survived the fire as stump and root systems that resprouted the following year (Table 3). There was no additional mortality of those genets in the four years following the fire. Bigtooth Aspen and Trembling Aspen also resprouted, but it was not possible to determine the number of individual genets.

The recruitment of new genets as measured by mapping occurred in only Red Oak, Pin Cherry, and Serviceberry (Table 3). There were as many or more new genets recruited in these species as old genets surviving the fire. In addition, two seedlings (13 genets/ha) of Paper Birch were noted in unmapped quadrats. All such recruitment was either by dispersal from outside the site or by seeds in the seed bank as no individuals on the site were large enough to reproduce.

Discussion

The nine tree species present in our study site showed differing proportions of recruitment by vegetative propagules versus seedlings. The aspen species reproduced exclusively by suckering and Red Maple by stump sprouting. Similarly, Paper Birch was recruited almost exclusively by stump sprouting. Paper Birch seedlings are commonly established in large numbers following burning (Fowells 1965). Lack of seed recruitment by the aspens and Red Maple was not due to lack of seed sources as large individuals of all species, including Paper Birch, were present on the borders of the study site.

Serviceberry and Red Oak were regenerated from both sprouts and seeds. Because stump sprouts generally grow faster and fruit at an earlier age than seedlings (Fowells 1965; Sharik et al. 1983; Ross et al. 1986), they are likely to contribute to the next generation earlier than individuals newly dispersed into the site. Pin Cherry is known to sprout to some extent, but the only mode of reproduction on this site was by seed. Finally, the pine species were completely dependent on recruitment through seeds from outside the site and no recruitment was observed in the first five years. Again, seed sources for the pines were present immediately adjacent to the site.

TABLE 3. Survivorship of previously established genets following the burn and recruitment of new genets from 1981 to 1984. There was no subsequent mortality in old genets surviving the fire. Means (SE) based on four 10 x 10 m quadrats.

Species	Number of old genets/ha surviving fire	Number of new genets/ha recruited
<i>Acer rubrum</i>	181 (28)	0
<i>Amelanchier arborea</i>	75 (31)	125 (38)
<i>Betula papyrifera</i>	25 (11)	0
<i>Prunus pensylvanica</i>	0	50 (20)
<i>Quercus rubra</i>	138 (33)	125 (40)

Measures of stem density immediately after disturbance can be somewhat misleading as predictors of long-term numbers. The type of vegetative propagation is also important. Red Maple accounted for 25% of the total stems in 1981. However, those stems were sprouting from only 43 stumps of only 32 genets, some genets having multiple trunks. It is reasonable to assume that only one or a few stems from each stump will survive. In contrast, the aspens arose as individual root sprouts and thus have the potential for higher rates of survival. We did not find evidence for differences in survival rates during the first three years after disturbance. However, in adjacent sites that were 30 and 36 years old Bigtooth Aspen continued to account for about 70% of total stems while only 10% of stems were of Red Maple (Sharik, unpublished data).

Mode of dispersal was correlated with recruitment by seed in the years immediately following disturbance. Seedlings of the animal dispersed species, Red Oak, Serviceberry, and Pin Cherry, were the majority of ones found. Seeds of several of the wind-dispersed species, including Red Maple, Eastern White Pine, Red Pine, and Paper Birch, have been found on the site, but we found only two seedlings of Paper Birch. Thus, the placement of seeds at microsites suitable for germination and establishment may be enhanced by animals compared to a more random and surficial placement by wind. No evidence for a seed bank (tested with a minimum resolution of 4 seeds m^{-2} in the upper 12 cm of the soil) has been found at these sites for any of the species considered in this study (Scheiner 1988) although seed banks of Pin Cherry (Bormann and Likens 1979) and Paper Birch (Livingston and Allesio 1968) have been found elsewhere.

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Brainworm, *Parelaphostrongylus tenuis*, in Moose, *Alces alces*, and White-tailed Deer, *Odocoileus virginianus*, of Nova Scotia

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Thomas, Janis E., and Donald G. Dodds. 1988. Brainworm, *Parelaphostrongylus tenuis*, in Moose, *Alces alces*, and White-tailed Deer, *Odocoileus virginianus*, of Nova Scotia. *Canadian Field-Naturalist* 102(4): 639–642.

A total of 213 White-tailed Deer (*Odocoileus virginianus*) and 92 Moose (*Alces alces*) heads, and 535 White-tailed Deer and 318 Moose fecal samples was examined for brainworm, *Parelaphostrongylus tenuis*, a nematode parasite. In deer, 50.7% of the heads and 64.7% of the feces were infected. In Moose, 6.5% of the heads and 12.7% of the feces were infected. The number of adult nematodes per infected deer head ranged from one to nine. In Moose only one had more than one nematode. No significant difference was found in infection rates of Moose and White-tailed Deer by age class or sex. The seasonal prevalence of *P. tenuis* fluctuated significantly ($P < 0.05$). There was no correlation between deer infection rates and deer density, nor were infection rates in Moose feces positively correlated to deer density.

Key Words: Brainworm, *Parelaphostrongylus tenuis*, Moose, *Alces alces*, White-tailed Deer, *Odocoileus virginianus*, Nova Scotia.

There has been considerable research in recent years on *Parelaphostrongylus tenuis*, a nematode parasite in the brain of White-tailed Deer, *Odocoileus virginianus*; this nematode is considered to be an important factor in the declines of Moose, *Alces alces*, and other cervids in areas where their ranges overlap that of White-tailed Deer (Anderson 1972; Gilbert 1974).

The Moose population in the eastern mainland counties of Nova Scotia is not increasing and may be declining. In 1963–1964, aerial surveys estimated numbers around 3600 animals. Population estimates, in 1965 of approximately 2886, in 1968 of 3072, and in 1976 of only 1200 Moose in the area (Telfer 1965; Prescott 1968; Scott 1976) appeared to confirm a decline.

Wildlife Division surveys in 1981, however, indicated a population between 2458 and 3456 animals, and in 1985 aerial inventory data indicated between 1990 and 2912 animals (Ross Hall and Arthur Patton, personal communication). Differences in weather conditions and census techniques may account for some of the observed variability and may indicate fluctuating rather than declining populations. A study of this population's reproduction (Vukelich 1977) suggested a declining population and Patton (1980), using harvest records, estimated that factors other than hunting accounted for 16 to 20% of the mortality in that year.

Between 1982 and 1985, Moose disease was believed by wildlife biologists to be an important mortality factor due to the number of Moose

reported each year exhibiting abnormal behavior associated with *P. tenuis* infection. It may also have contributed to both accidental kills and illegal hunting mortality (Table 1).

The present study reports on the occurrence and distribution of *P. tenuis* in Moose and White-tailed Deer in 1980–1981 in Nova Scotia, including two eastern mainland counties where open hunting seasons have been held irregularly since 1964.

Methods

Estimates of the prevalence of *P. tenuis* in Moose and White-tailed Deer were based on the frequency of infection in a sample of heads and feces collected throughout the province. Most of the Moose heads were collected during the 1980 and 1981 hunting seasons. Some heads were from accidental kills and from Moose killed after exhibiting abnormal behavior typical of brainworm infection. Deer heads were mainly from road kills and accidental kills. Any heads that were damaged or decomposing were not included. Each head was partially skinned, the brain exposed by four cuts with a bone saw, and the exposed portions of the meninges and the brain surface were examined for adult *P. tenuis*. The meningeal blood vessel was slit and the lumen examined. The brain, as well as the brain case and spinal cord, when present, were then removed and examined. The number and location of adult *P. tenuis* were recorded and the parasites were preserved in 10% formalin for sexing.

Moose feces were obtained from animals killed by hunters during the 1981 Moose season, and by

TABLE 1. Moose observations and causes of Moose mortality in Nova Scotia (total province) and its five eastern mainland counties, 1982-1985.

YEAR	AREA	CAUSE OF MORTALITY											
		Hunter killed		Illegal hunting		Accidents ³		Diseased ⁴		Unknown		Total	
		# ¹	% ²	#	%	#	%	#	%	#	%	#	%
1982	Province	18		3		15		12		9		57	
	5 Counties	7	39	1	33	6	40	10	83	5	56	29	51
1983	Province	15		8		10		4		13		50	
	5 Counties	7	33	7	88	7	70	3	75	8	62	32	64
1984	Province	13		3		17		17		8		58	
	5 Counties	5	38	3	100	11	65	13	76	4	50	36	62
1985	Province	17		10		10		9		12		58	
	5 Counties	3	18	8	80	6	60	9	100	7	50	33	57
Total	Province	63		24		52		43		42		224	
	5 Counties	20	32	19	79	30	58	35	81	24	88	128	57

Data from Wildlife Division Reports (Ross Hall and Arthur Patton, personal communication).

¹# = Number of heads examined.

²% = Percent of heads infected with adult *P. tenuis*.

³Accidents includes automobile, train, drowned, bear killed and miscellaneous deaths.

⁴Moose exhibiting abnormal behavior associated with *P. tenuis* infection.

Wildlife Division biologists from miscellaneous Moose kills. Deer feces originated primarily from road-killed deer. In addition, six study areas with low and high Moose and White-tailed Deer densities (based upon regional biologists' estimates) were chosen for seasonal feces sampling. This was carried out by regional biologists and the authors by searching each study area for at least two days each season for two years.

In area one, an area of low deer-low Moose density of approximately 2.2 square kilometers in Halifax County, 64 deer and 85 Moose feces were collected. In area two, an area of low deer-no Moose density of approximately 0.4 square kilometers in Kings County, 187 deer feces were collected. In area three, an area of low deer-high Moose density of approximately 3.3 square kilometers in Shelburne County, 30 deer and 39 Moose feces were collected. In area four, an area of high deer-low Moose density of approximately 0.8 square kilometers in Colchester County, 80 deer and 38 Moose feces were collected. In area five, an area of high deer-no Moose of approximately 0.1 square kilometers in Richmond County, 26 deer feces were collected. In area six, an area of high deer-high Moose density of 3.0 square kilometers in Pictou County, 42 deer and 15 Moose feces were collected. Some feces may have come from the same individuals within the study areas. All feces were examined for first stage *P. tenuis*-like larvae

using the Baermann Technique as described by Todd et al. (1970). Larvae can only be positively identified to genus but *P. tenuis* is currently the only known species to occur in Nova Scotia or eastern Canada.

All data from heads and feces were summarized by host, kill type or collection area, sex and age of the host species, season, month, year, number, sex and location of adult worms. Data were analyzed in the computer sub-program "Crosstabs" of the Statistical Package for the Social Sciences (SPSS). Tests for significance ($P < 0.05$) were done using chi-square and regression analysis to determine whether or not data variables were statistically independent.

Results

Parelaphostrongylus tenuis was found in White-tailed Deer throughout the province. Of the 213 deer heads examined, 50.7% were infected with adult nematodes. White-tailed Deer feces were found to have an infection rate of 64.7%. Three hundred and forty-six of 535 fecal samples were positive for first stage larvae similar to *P. tenuis*.

Neither Moose nor White-tailed Deer showed significant differences in infection rates in the number of worms by age class or sex ($P > 0.05$). The number of worms per infected deer head ranged from one to nine with a mean of 1.9 worms in female White-tailed Deer and 2.3 worms in

TABLE 2. *Parelaphostrongylus tenuis* infection in White-tailed Deer and Moose by season from Nova Scotia.

SEASON	DEER				MOOSE			
	Heads		Feces		Heads		Feces	
	# ¹	% ²	#	%	#	%	#	%
Winter	60	47	307	69	7	29	110	19
Spring	14	57	7	72	1	0	34	21
Summer	52	35	95	42	5	20	44	11
Fall	71	65	51	65	66	5	129	6
Total	197	51	523	64	79	8	317	13

¹# = Number examined.²% = Percent infected.

males. Only one infected Moose head, that of a female, had three adult *P. tenuis*, all others only one. The seasonal abundance of *P. tenuis* fluctuated in both White-tailed Deer and Moose (Table 2). Although infection rates were significantly different ($P < 0.05$) in deer feces from the six collection areas, there was no correlation between deer infection rates and deer density (Table 3), nor were the infection rates in Moose feces positively correlated to deer density. Infection rates in Moose feces were positively correlated to deer infection rates.

Discussion

Infection rates in both heads and feces of Moose were higher in this study [7.6% and 12.9%, respectively] than found by Hansen (1975) [4.2% and 5.8%], suggesting that more Moose may be infected and that some may be surviving, at least until larvae are first passed in feces.

Parker (1966) has suggested that spring and early summer are times of maximum infection in Nova Scotia. Not only are the intermediate gastropod hosts most abundant then, but White-tailed Deer are leaving wintering areas and feeding on newly exposed vegetation and accidentally ingesting infected gastropods. During winter the *P. tenuis* larvae can cease development and overwinter in the foot of the gastropod host, halting infection until the weather is milder. Conditions favoring transmission deteriorate during extremely hot summer weather (Lankester and Anderson 1968). Feces tend to dry out quickly in summer, causing larvae to die. First stage larvae can be found in feces about three to five months after ingestion of gastropods containing the infective third larval stage. Therefore, after infected gastropods are ingested in the spring, a peak in infected feces should be expected in the fall and early winter.

TABLE 3. *Parelaphostrongylus tenuis* infection rates in White-tailed Deer and Moose feces, and the infection rates in relationship to the relative densities of White-tailed Deer and Moose numbers (from study areas in six counties).

Study Area	Relative Density of Deer vs. Moose	County	Deer		Moose	
			# ¹	% ²	#	%
1	Low deer: low moose	Halifax	64	53	85	15
2	Low deer: no moose	Kings	187	75	—	—
3	Low deer: high moose	Shelburne	30	83	39	28
4	High deer: low moose	Colchester ³	80	73	38	18
5	High deer: no moose	Richmond	26	46	—	—
6	High deer: high moose	Pictou ³	42	41	15	7
Total			429	67	177	18

¹# = Number of feces examined.²% = Percent infected with larvae similar to *P. tenuis*.³Representative eastern mainland counties where census data have been obtained and open hunting seasons have been held sporadically since 1964.

The highest infection rates in Moose feces in this study were found in winter and spring, suggesting that larvae were ingested in the summer and fall. Several authors have found that the greatest distributional overlap of Moose and White-tailed Deer occurs during summer and fall (Telfer 1965; Irwin 1975).

It has been suggested that *P. tenuis* can cause declines of Moose populations, especially in areas of high deer density (Karns 1967; Gilbert 1974). Although there is no evidence that the parasite can establish itself in Moose populations without the presence of deer, Anderson (1964) noted that there was a comparable rate of development of *P. tenuis* in Moose and deer. The large numbers of worms recovered in this and other studies suggested that Moose might serve as suitable definitive hosts if they survive the neurologic damage that may result from infection. *Parelaphostrongylus tenuis* can apparently complete its life cycle in Moose at least part of the time without killing the host. Other studies also provide evidence that some Moose are surviving *P. tenuis* infestations (e.g. Anderson and Prestwood 1981). In Maine, Moose populations have been increasing and hunting has been resumed; declining White-tailed Deer numbers have been suggested as part of the reason for the increase in Moose (Dunn and Morris 1981). While *P. tenuis* may not be the principal mortality factor in Nova Scotia Moose, it may be important in spite of the observation of some Moose surviving with *P. tenuis* made during this study. Other mortality factors, such as poaching or habitat changes caused by forestry practices, need to be assessed in order to understand the relative role of *P. tenuis* in the decline of Nova Scotia's Moose population.

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Arctic Adaptations in the Breeding Biology of Sandhill Cranes, *Grus canadensis*, on Banks Island, Northwest Territories

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The Lesser Sandhill Cranes (*Grus canadensis canadensis*) nesting on Banks Island, Northwest Territories, possess several behavioral and ecological traits that appear to be adaptations to high Arctic conditions and differ from those of the same subspecies on the mainland. On southern Banks Island cranes inhabit sand dune and dry tundra habitat adjacent to lakes, ponds and rivers. The three breeding pairs of cranes in the 16-km² study area had a mean territory size of 1.3 km² compared to 0.6 km² for the four non-breeding pairs. Nests were located in sand dune regions, apparently to avoid fox predation. Parental care included much under-wing brooding and direct bill-transfers of tubers to the chicks. On one occasion a parent carried a chick on its back while feeding — the first report of such behavior among cranes. Sibling aggression often accompanied parental feeding. Seven methods of foraging were recorded, including lemming (*Dicrostonyx* and *Lemmus* spp.) hunting in which a crane adopted a special posture enabling it to look down lemming burrows. On seven occasions cranes were observed capturing and consuming lemmings. Because of late spring and early fall migrations, cranes inhabiting the Arctic Islands have a truncated breeding season compared to continental populations.

Key Words: Sandhill Crane, *Grus canadensis*, Banks Island, breeding biology, arctic adaptations.

Little is known about the Sandhill Cranes, *Grus canadensis*, that breed in the Canadian Arctic, especially in the Arctic Archipelago. The cranes nesting north of approximately 60° N latitude from eastern Siberia to western Hudson Bay are classified as Lesser Sandhill Cranes, *Grus c. canadensis*, (Walkinshaw 1949, 1973). Although the breeding range of this subspecies is vast, nearly all that is known about these birds is derived from studies in western Alaska (Walkinshaw and Stophlet 1949; Boise 1977). During a brief visit to Banks Island, Northwest Territories — the westernmost island of the Arctic Archipelago 650 km north of the Arctic Circle — Walkinshaw (1965) noted that the cranes nesting there appeared smaller and differed in a number of respects in their behavior and ecology from their western Alaskan counterparts. Walkinshaw's observations indicated that this subspecies may include several distinct breeding populations, each adapted to its own environmental conditions. With the resumption of crane hunting in North America, the identification of small, locally-adapted populations of cranes, whose existence may be threatened by hunting pressure, is essential to preserving the genetic diversity of this species. In order to better understand the distinctiveness of the Banks Island cranes and more generally the differences between those breeding in the Arctic Islands and the mainland, I studied the breeding biology and arctic adaptations of Banks Island cranes.

Study Area and Methods

The 16-km² study area is located 12 km ESE of Sachs Harbour and 3 km N of the coast (71° 55' N, 125° 02' W) on Banks Island, Northwest Territories. Southern Banks Island is dotted with tundra lakes, ponds and rivers of varying sizes. The vegetation of the study area resembles that of adjacent Victoria Island as described by Parmelee et al. (1967), who classified tundra into various zones. Wet tundra, located between bodies of water and dry tundra, is well vegetated, hummocky ground dominated by *Salix* and *Carex* spp. Low-elevation dry tundra on Banks Island, composed of moderately dense vegetation only a few centimeters tall, is essentially identical to that described by Parmelee et al. (1967) on Victoria Island. Sand dunes, which cover extensive areas of southern Banks Island, are devoid of vegetation except for patches of Lyme-grass, *Elymus arenarius* (Porsild 1957: 41). Marsh and high-elevation dry tundra, present elsewhere on the island, are absent in the study area. Mean summer temperatures at Sachs Harbour usually range from 2 to 6°C; winds upwards of 30 km/h with horizontally blowing snow (which melts shortly after falling) are not uncommon during June and August, though July is milder.

Two field assistants and I observed crane behavior from tents and in the open using binoculars and high-powered telescopes and conducted censuses on foot from 2 June to 15

August 1976. I also interviewed Inuit in Sachs Harbour for additional information on migration dates, distribution and feeding habits of these birds. Territory sizes were inferred from censuses conducted twice per week (individual characteristics, e.g., strange coloration or limping, were often observed), nest locations, and observations of agonistic encounters indicative of boundary disputes, e.g., "alarm calling" (Walkinshaw 1949: 22) and pulling and tossing of vegetation.

Once a week we captured and measured three crane chicks in the study area, two of whose hatching dates were known precisely. The following linear measurements were recorded: exposed culmen, tarsus, midtoe without claw, and outstretched wing chord. Chicks were banded and colour-marked (3 × 10 cm lime-green, plastic patagial-tags) 40 to 45 days after hatching. To determine if egg dimensions of cranes from Banks Island and western Alaska were different, a short-cut parametric test (Natrella 1963: 15-3) was selected because only the mean and range of measurements are given for 91 Alaskan eggs by Walkinshaw (1973: 103).

Results and Discussion

Spring migration

Cranes usually arrive at Banks Island about 15 May (Manning et al. 1956; Walkinshaw 1965), while Alaskan cranes arrive on their breeding grounds between 55° and 65° N latitude between the last week of April and the middle of May (Walkinshaw 1973: 99; Boise 1977; Kessel 1984). In 1976 I arrived on Banks Island too late to witness any but the end of the spring migration. On 3 June I observed my first cranes, three birds flying north far over the pack ice toward the island. They landed on a ridge 2 km west of Sachs Harbour and immediately began feeding; presumably, these birds had just migrated from the mainland. Four Inuit who hunt in the southern part of the island reported seeing their first cranes of the season on 26 April, 30 April (three cranes), 1 May and 5 May 1976. These exceptionally early arrival dates may reflect the unusually early spring experienced in the north that year. Snyder (1957) misjudged the arrival dates of cranes in the Arctic when he stated that they start returning to the southern Arctic by the end of May and are established over their entire range by the third week of June.

Distribution

According to Manning et al. (1956) approximately 3000 cranes occur on Banks Island with highest concentrations along the Muskox, Thompson and Bernard rivers in the north-central

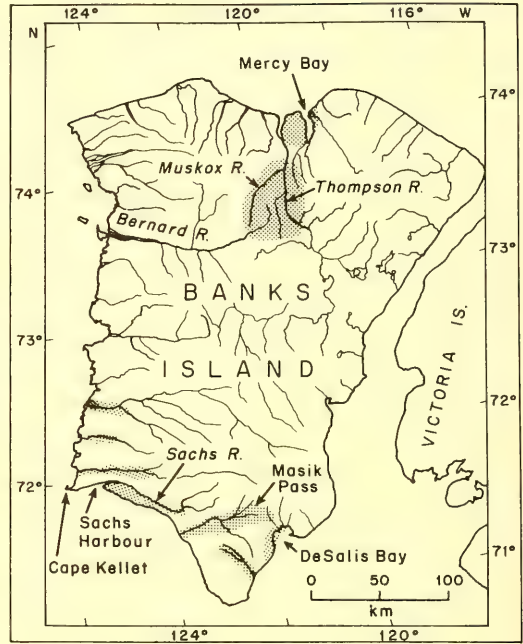


FIGURE 1. Breeding distribution of Sandhill Cranes on Banks Island, Northwest Territories.

part of the island (Figure 1). The cranes prefer broad, flat valleys that have been cut through hilly country or areas sheltered on the north by long escarpments (Manning et al. 1956). Cranes south of the Sachs River occupied territories composed of extensive stretches of sand dunes and dry tundra adjacent to lakes, ponds or rivers.

Territories and Density

The study area contained seven pairs of Sandhill Cranes, who had a mean territory size of 0.9 km². The three pairs that nested occupied territories of 1.8 km² (two-chick family), 1.1 km² (one-chick family) and 0.9 km² (a pair that deserted its nest with one egg.) The territories of the two pairs that successfully reared young were composed of three habitat types: (1) an extensive area of sand dunes for nesting, (2) dry tundra for feeding, and (3) wet tundra around ponds and small lakes for feeding and drinking. Territory sizes of the four non-breeding pairs were 0.3, 0.4, 0.5, and 1.4 km². The only local cranes seen outside the study area were a pair sighted on 18 June during one of five walks from Sachs Harbour and another pair with one chick seen 4 km northeast of the study area on 25 June. Therefore, I believe that only 8 to 9 pairs of cranes had territories in the 80-km² area of

southern Banks Island encompassing my study area. Of the eight pairs of cranes that Walkinshaw (1965) found in an area of over 64 km², four had two-egg nests. Walkinshaw's 2.9-km² estimate of territory size was calculated by dividing his study area by 2 (he thought that one-half of his study area was unsuitable for cranes) and then by 8 (number of pairs). Boise's (1977) two-year estimates of mean nest densities of 0.54 and 0.78 nests/km² at Old Chevak, Alaska, indicate that cranes probably occur at much higher densities in western Alaska than in the Arctic Islands.

Nesting

Nest-site selection and construction in Banks Island Sandhill Cranes differs from that of Alaskan (and Siberian) Sandhill Cranes. Whereas Alaskan cranes construct tall nests in wet marshes and sedge-grass meadows (Boise 1977) and eastern Siberian cranes build similar nests in wet, brush-covered tundra up to elevations of 1000 m (Dement'ev and Gladkov 1951: 114-116), the three nests that I found on Banks Island were of simple construction and located in extensive sand dune regions. On 9-10 June a nest with two eggs in it and a one-egg nest were found 2.2 km apart; a third, empty nest found on 12 July was located 1.5 and 3.0 km, respectively, from the other two nests. I discovered the first two nests by following crane tracks to the nests from a site in the dunes where I heard alarm calling.

The first nest was located on one of the highest dunes in the vicinity (2.3 m high) and measured 40 cm in diameter and 8 cm in depth. The outer one-third diameter was lined with approximately 100, 25-cm-long pieces of lyme-grass. The nest contained two eggs measuring 56.4 × 84.5 and 54.4 × 83.5 mm. The second nest was placed on a dune 2 m high, measured 23.5 cm in diameter and 5 cm in depth, and contained one egg measuring 54.3 × 91.0 mm. On 26 June the sole egg in the latter nest was tepid yet there were crane tracks in the immediate vicinity; three days later no egg or tracks were seen and the grass that once lined the nest was scattered about. The nest found on 12 July was in a 5 × 6 m grassy area among high sand dunes; it was inconspicuous and protected from the wind; it was nearly flat (3-cm depression) and composed of approximately 250 pieces of lyme-grass. Five reddish-brown flight feathers were found in the nest depression.

Parental care

The following describes activities of the two-chick family at the time of hatching of the eggs. The chick inside the smaller egg from the two-egg nest

(most observations of parental care were obtained from this two-chick family) was heard peeping at a rate of 6 peeps/10 s at 2300 h on 25 June. Twenty-four hours later both chicks were calling at a rate of 12 peeps/10 s and both eggs were pipped at the blunt ends. Upon inspecting the nest at 1900 h on 27 June, I discovered that the chick from the smaller egg had just hatched; I weighed and measured it at this time. (Alaskan crane eggs hatch between 14 June and 1 July; Boise 1977). The incubating parent, later discovered to be the male (see below), resumed sitting on the nest after I departed and remained there for 30 min until it was replaced by its mate. The male moved 100 m away from the nest and gave his part of the unison call (Walkinshaw 1949: 22). For the next 12 h 39 min the female brooded the chick under her wing while incubating the remaining egg. The male relieved his mate at 08:10 h the next morning and left the nest only once for 43 min until he gave his part of two unison calls at 18:58 h and was relieved 1 min later by the female.

After 2 h 26 min of her 17-h incubation shift had elapsed, the female, followed by the chick, left the nest and walked down the dune where she met the male. The female then resumed incubating while the chick remained with the male following him at a distance of 2-6 m, often stumbling as it ran. Whenever the male stopped to feed on tubers, the chick solicited food by pecking at the distal one-third of the parent's bill. All subsequent observations of parental feeding involved beak to beak transfer of food or regurgitation-like behavior by the parent followed by the chick pecking at the ground in front of the parent. At approximately 30-min intervals the male sat down and the chick — apparently seeking shelter from the 0°C temperature, high winds and blowing snow — moved under a wing of the adult or climbed on the parent's back, nestling between its wings. Both types of brooding behavior lasted 5-10 min. On one occasion the male stood up with a chick still on its back. Only the chick's head could be seen protruding above the adult's wings (Figure 2). The male walked about and foraged but did not feed the chick. It appeared that the parent compressed its wings around the body of the chick so as not to drop it. After 5 min the parent sat down and the chick climbed from its back. To my knowledge this "carrying" behavior has not been reported before in cranes.

After the second chick left the nest at 12:15 h on 29 June, both young were fed and brooded by both parents. I first saw independent feeding by young on 12 July when the larger chick ate tubers on its

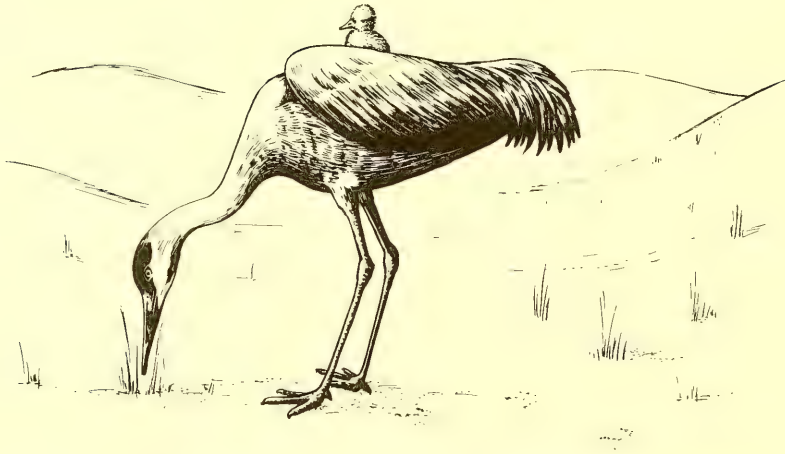


FIGURE 2. Male parent carrying a chick 27 h of age on its back while foraging, Banks Island, Northwest Territories.

own, and my last observation of brooding, on 14 July, involved the smaller chick. Both chicks, however, were mostly fed by their parents throughout the duration of the study.

Sibling aggression

I saw the first of 10 sibling aggressive encounters 30 h after the second chick left the nest. The older chick ran with outstretched wings over to its sibling (which was being fed by a parent) and began pecking at it. The younger chick ran away and the parent began feeding the older chick. Within a week sibling dominance was established — the older chick had only to approach the younger one as it was being fed to cause the latter to flee. I saw no sibling aggression in any other context. Although the chicks were approximately the same size at hatching, their growth rates soon began to differ (Figure 3), perhaps reflecting their differential access to food (gender difference in growth rates is another possibility.) The smaller chick's development, however, began to catch up with that of its sibling 40 to 45 days after hatching.

Feeding habits

I recorded seven different methods of foraging, at least one of which — lemming hunting — appears to be specifically adapted to the high arctic environment. In grassy wetlands cranes pulled up grasses and sedges and ate the tubers. In this same habitat they also apparently searched for arthropods under clumps of plants, but I was uncertain what they were actually eating. Most

feeding occurred in dry tundra where four distinct feeding techniques were employed. Until mid-July, the cranes followed a pattern of walking three to six steps, pecking at the tundra approximately six times and then ingesting something. After many observations and repeated searches of foraging sites, I could not determine what they were eating — perhaps small insects. By mid-summer cranes were feeding primarily on tubers of Arctic Willow (*Salix arctica*), which they obtained by snipping off the flower spikes and then jabbing their bills into the ground around the tubers.

I saw cranes hunt Collared, *Dicrostonyx groenlandicus* and Brown lemmings, *Lemmus trimucronatus*, on 7 and 9 June, 7, 14 and 26 July, and 2 August. On these occasions cranes adopted a specific stalking posture in which they lowered their outstretched necks and heads and then looked from side to side. This posture evidently allowed them to peer into lemming burrows. When a lemming was detected, the crane thrust its bill into the burrow or, if the lemming was above ground, the crane chased it. If captured, the lemming was shaken, thrown into the air and then stabbed with the beak until torn into several pieces. The only mention of the occasional taking of lemmings in Alaska is by Nelson (1887: 94). Harvey et al. (1968) provide the only other report of lemming predation by cranes; this involved a collared lemming found in the stomach of a crane from McConnell River on the western shore of Hudson Bay. Cranes also ate chicks of Black-

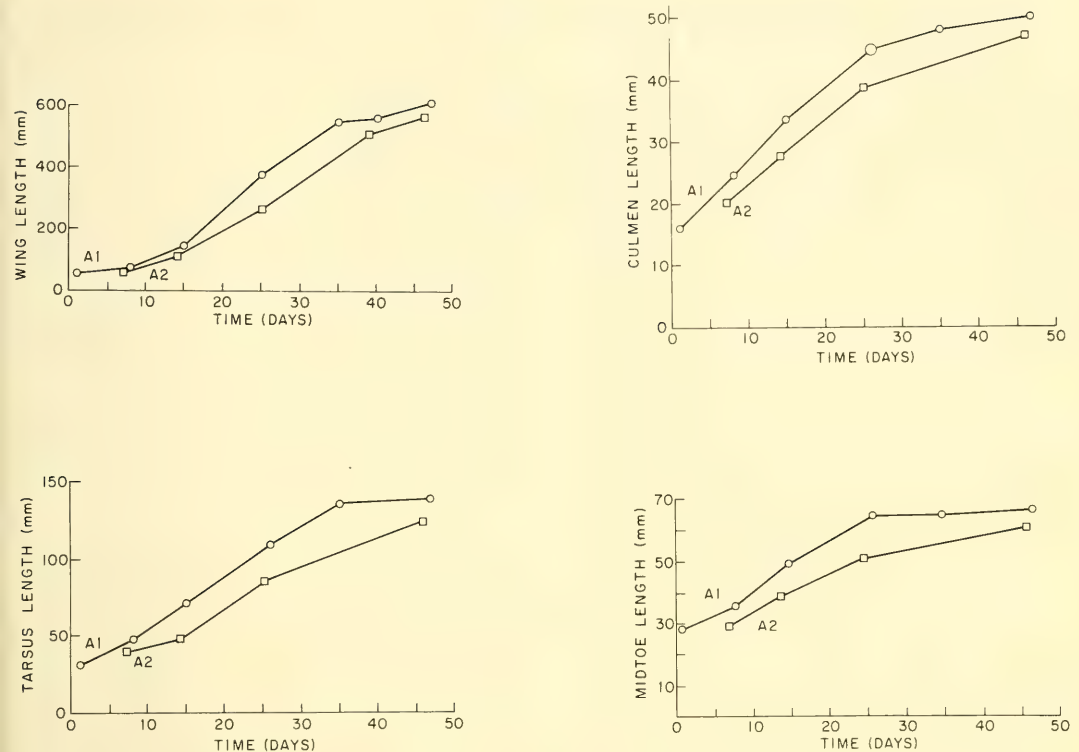


FIGURE 3. Developmental rates for two sibling crane chicks. Chick A1, approximately 24 h older than A2, is dominant. Chick A2 was first measured seven days after it hatched.

bellied Plovers, *Pluvialis squatarola*, on 8 and 28 July. On five occasions in late June, after the eggs hatched, I saw cranes foraging on lyme-grass in sand dunes but I could not determine if insects or fruit spikes of the grass were being taken.

Predators

The only potential predator of cranes was the Arctic Fox, *Alopex lagopus*, and its absence in the sand dunes may account for cranes nesting there. When my assistants and I approached a crane family to measure the chicks, the parents led the young to the dunes, whereupon the adults uttered loud alarm calls and ran or flew in different directions. When one of us sighted a chick and approached it, both parents usually flew back to it. One parent then tried to divert our attention by giving alarm calls and strutting in front of us with its head held close to the ground, while the other parent led the chick away from us. The cranes were often successful at eluding us, especially as the chicks grew older.

Fall migration

The prelude to fall migration in 1976 occurred on 28 July with the arrival of a group of 10 cranes not previously seen on the study area. Non-breeding pairs within the study area began leaving their territories shortly after the first snowfall on 1 August. About half of all cranes had left their territories for staging areas on Banks Island or the mainland by 15 August, the last day of the study. Inuit reported more than 300 cranes staged for migration at Masik Pass (60 km east of the study area) in the latter part of August 1975. In 1953 the last dates for crane sightings along the north coast of Banks Island were 24 August and 1 September (Manning et al. 1956). Inuit reported most cranes leave Banks Island by 1 September. Alaskan cranes depart their breeding areas much later; large flocks of up to 3000 cranes were observed near Mt. McKinley between 10 September and early October (Dice in Walkinshaw 1973: 104-105), and Kessel (1984) reported 150 000 to 200 000 Sandhill Cranes migrated through the upper Tanana River

Valley of eastern Alaska from the last week of August to the first week of October.

Conclusions

The breeding biology of the Sandhill Cranes on Banks Island appears to be specifically adapted to high arctic conditions and hence differs in many respects from that of the Lesser Sandhill Cranes breeding in western Alaska. Furthermore, my inspection of the published measurements of Lesser Sandhill Cranes confirms Walkinshaw's impression that Banks Island cranes are smaller than their Alaskan counterparts. Since most taxonomic designations are based on morphological rather than behavioral information, I recommend that study collections of cranes be made from the Arctic Islands, western Hudson Bay and along the Arctic coast in order to ascertain if recognition of a distinct subspecies of Arctic Sandhill Crane is warranted. The report of Conant et al. (1985) showing an increase in the Alaskan Sandhill Crane population during the re-establishment of crane hunting from 1957 to 1985 is encouraging, yet these results may have little relevance to the status of the smaller Sandhill Crane populations in other parts of the Arctic. The first step in assessing the impact of hunting on Arctic cranes is to determine if one or more distinct breeding populations are represented. If this proves to be the case, censuses should be conducted to ascertain both the range and size of each population.

Acknowledgments

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Two Pussy's-toes, *Antennaria alborosea* and *A. stolonifera*: Additions to the Vascular Flora of Alberta

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Chmielewski, J. G., and C. C. Chinnappa. 1988. Two pussy's-toes, *Antennaria alborosea* and *A. stolonifera*: additions to the vascular flora of Alberta. *Canadian Field-Naturalist* 102(4): 649–652.

The first records for *Antennaria alborosea* A. E. Porsild and *A. stolonifera* A. E. Porsild are reported for the flora of Alberta. The species are readily distinguished from closely related taxa once the range of variation in diagnostic characters is realized.

Key Words: *Antennaria alborosea*, *Antennaria stolonifera*, range extension, flora, Alberta.

Moss (1983) listed 14 species of *Antennaria* Gaertner (pussy's-toes, sometimes also called everlastings but the latter is shared with at least two other genera) for the vascular flora of Alberta. Argus and White (1978) considered six species of *Antennaria* to be rare in Alberta (*A. acuta* Rydb., *A. alpina* (L.) Gaertner var. *media* (Greene) Jeps., *A. angustata* Greene, *A. corymbosa* E. Nels., *A. luzuloides* T. & G., and *A. monocephala* DC. ssp. *monocephala*). Most recently, Packer and Bradley (1984) listed *A. corymbosa*, *A. dimorpha* (Nutt.) T. & G., and *A. luzuloides* as rare in Alberta. Range extensions reported here for two previously presumed arctic species *A. alborosea* A.E. Porsild and *A. stolonifera* A.E. Porsild are the incidental result of field work and the examination of herbarium specimens predominantly of Section *Dioicae* from ALA, ALTA, ARIZ, BHSC, CAN, COLO, DAO, GFND, IDS, KANU, MIN, MONT, NDA, NEB, NESH, NMC, NY, OSC, RM, UAC, UBC, UNM, US, USAS, WIN, WS, and WTS (Holmgren et al. 1981) for the purpose of studying intraspecific variation within the section.

Antennaria alborosea A. E. Porsild

Flowering stems of *A. alborosea* may be 2–50 cm high (usually 10–30), slender, glandular, and greenish purple in color. The species is apomictic and produces 2–40 (usually 5–15) capitula which contain 30–90 florets. The involucre is 5–8 mm high and the phyllaries are 3–4 seriate. The upper one-half to two-thirds of the phyllaries are usually pink to red in color, but occasionally may be straw colored. The style is rarely exserted, and if so, only slightly. The achenes are dusky brown and may be glabrous or minutely to densely papillate.

Some floristicicians have not recognized the species and considered it to be conspecific with *A.*

rosea Greene (e.g., Welsh 1974; Scoggan 1979), whereas others have recognized *A. alborosea* at the rank of species (e.g., Hultén 1968; Porsild and Cody 1980). Based on our studies of western North American *Antennaria* (Chmielewski and Chinnappa 1988a,b,c) we support the viewpoint of Hultén (1968) and Porsild and Cody (1980) that *A. alborosea* is a separate species.

Although *A. alborosea* and *A. rosea* are similar in habit, *A. alborosea* can be readily recognized from *A. rosea* by the former's glabrous-glabrate basal and cauline leaves (particularly the adaxial surface) and its conspicuous glands on the basal leaves, cauline leaves and stem.

Antennaria alborosea occupies a range of habitats which include thickets, pine-spruce slopes, alpine slopes, river banks, alluvial flats, roadsides, shrub savannah, and granitic outcrops.

The earliest collection we found was made by A. J. Breitung et al. (2835) in August 1946 from the south slope of Observation Mountain, Banff National Park (DAO 123086). In July 1967 P. W. Stringer (s.n.) also collected a specimen in Banff National Park, 4 miles up Johnston Creek (ALTA 41683). In August 1949 G. H. Turner (6886) collected a specimen from Honeymoon Lake about 32 miles south of Jasper in Jasper National Park (ALTA 66023). More recently (July 1986), B. Smith and J. G. Chmielewski (CC2670) collected a specimen from Maligne Lake, Jasper National Park (UAC 46038). The species was relatively common in the wooded area around the Maligne Lake parking lots. We are aware of only two collections from outside the boundaries of these National Parks in western Alberta. M. G. Dumais and P. J. Scott (5643) collected a specimen (July 1971) just east of Jasper National Park, 5 miles south of Cadomin (ALTA 38181). P. van Eck and

J. Corbin (s.n.) located a specimen (August 1978) north of Jasper National Park, approximately 0.75 miles downstream from lower Kakwa Falls on the Kakwa River (UAC 42979).

The specimen which we collected from Maligne Lake was tetraploid ($2n = 56$, Chmielewski and Chinnappa 1988b). The species was previously reported as tetraploid and pentaploid ($2n = 70$) for more northern locations (Chmielewski and Chinnappa 1988a).

Prior to this report, *A. alborosea* was described from the Pelly Range in southeastern Yukon (Porsild 1946) and later reported to occur in central Alaska, central and southeast Yukon, east to Bear Lake, and south to the mountains of southeast Alaska and northern British Columbia (Porsild 1950). In addition to the collections from southern Alberta, we have identified a number of collections from central to southern British Columbia (D. A. Mitchell (153) 13 July 1949, Bennett DAO 304336; H. J. Scoggan (15067) 26 June 1964, between Princeton and Penticton ALTA 43441; H. J. Scoggan (15678) 16–20 July 1964, Kamloops and vicinity ALTA 43442; V. J. Krajina (65062480) 24 June 1965, south of Princeton DAO 614796; R. L. Taylor et al. (5747B) 15–25 August 1972, mountains north of Anahim Lake DAO 199719; B. Lemon (3-036) 31 May 1976, Bennett DAO 304336; and G. A. Hardy (19844) Skagit Valley DAO 466160), Montana (R. Bayer and G. L. Stebbins (M-344) 15 August 1983, Granite County, Crystal Creek Campground RM 362763, reported as *A. rosea* toward *A. racemosa* $2n = 56$ in Bayer and Stebbins 1987), Oregon (H. M. Gilkey (s.n.) Wallowa County, Lostine River OSU 113924; and J. Mastrogiuseppe and H. Snodgrass (1980) Union County, Wallowa Mountains WSU 284201), and Wyoming (H. C. Cantelon (s.n.) 10 July 1942, Teton County, near Jackson Lake CAN 281461). The species was not previously reported from Montana (Booth and Wright 1959; Dorn 1984), the flora of the Pacific Northwest (Hitchcock and Cronquist 1973), or the flora of Wyoming (Dorn 1977). These reports extend the species' range approximately 1500 km further south than initially described.

Antennaria stolonifera A. E. Porsild

Flowering stems of *A. stolonifera* are 5–20 cm high, robust, and stiffly erect. Pistillate plants produce 1–12 capitula, with 3–5 being the most common number produced. The involucre are 5–7 mm high and the phyllaries are 3 seriate. The outer phyllaries are densely lanate, with obtuse greyish tips, whereas the inner are linear-oblong

with obtuse olivaceous tips (Porsild and Cody 1980). The style is barely exerted. Achenes are dark brown, approximately 0.8 mm long, and are covered with hispid papillae.

Porsild (1950) stated that *A. stolonifera* extended south through the Canadian Rockies to Banff National Park. Subsequently, Porsild and Cody (1980) excluded the species from southern Alberta, possibly because of intergradation or confusion with *A. media* Greene. Moss (1959, 1983) did not recognize *A. stolonifera* as occurring in southern Alberta.

Variation in growth form of the capitula, number of flowers, and phyllary coloration distinguish *A. stolonifera* from *A. media*. However, the best character with which to separate the taxa is the growth form of the capitula. The capitula of *A. stolonifera* occur on short (1–3 cm long) peduncles, which upon maturation elongate such that they either reach or surpass the height of the central heads. The capitula of *A. media* occur on short peduncles and form a dense, compact cluster.

Of the nine specimens of *A. stolonifera* from Alberta which we examined, eight were from Banff or Jasper National Parks and one was from Plateau Mountain in southwestern Alberta. The latter was collected in July 1985 by B. Smith (626, UAC 45744). In July 1986 B. Smith and J. G. Chmielewski collected a specimen (CC2679) from Maligne Lake, Jasper National Park (UAC 46039). This is the only collection we have seen from this park. Six specimens have been collected from Banff National Park. The earliest collection we found was made by A. J. Breitung et al. in August 1946 from the south slope of Observation Mountain (DAO 123101). In August 1985, C. C. Chinnappa and B. Smith collected two specimens (CC1956, and CC1954) from Sunshine Village Ski Resort (UAC 45749, and 45750). In July 1986 B. Smith and J. G. Chmielewski located several clones (CC2717) near the parking lot of Moraine Lake (UAC 46040). Two specimens (CC2135, and CC2136) were collected one month later by J. G. Chmielewski and C. M. Leuty from the nearby slopes of Lake Louise Ski Resort (UAC 46041 and 46042). Voucher specimens UAC 46039 and 46041 were determined to be tetraploid ($2n = 56$), whereas UAC 46040, 45744, and 45749 were pentaploid ($2n = 70$, Chmielewski and Chinnappa 1988b).

Prior to this report, *A. stolonifera* was described as locally common in central Alaska, central and southeast Yukon, and as occurring on the east slope of the Mackenzie Mountains (Porsild and

Cody 1980). A questionable entity (similar to *A. media*) extended south through the Canadian Rockies to Banff National Park (Porsild 1950). In addition to the specimens listed above for Alberta we also identified specimens of *A. stolonifera* from central British Columbia, Paxton Mountain (ALTA 49795), Mount Revelstoke National Park (CAN 342309), and the international border between British Columbia and Washington State (ALTA 39650).

Discussion

Two factors are probably responsible for these species not being previously reported from Alberta. First, the genus as a whole is taxonomically difficult (Chinnappa 1986), especially Section *Dioicae* to which *A. alborosea* belongs and Section *Alpinae* to which *A. stolonifera* belongs. *Antennaria alborosea* and *A. stolonifera* are probably more common in the Rockies than herbarium collections, or at least present identification of herbarium specimens, reflect. Misidentification of previously collected specimens has resulted in the omission of these species from the local flora. When the taxonomically problematic groups in the genus are revised it is likely that several more species will be found to occur in the flora of Alberta. Biosystematic studies of western North American *Antennaria* in progress in our laboratory will hopefully help to rectify this problem. The lack of previous reports from southern Alberta and other more southern locations represent taxonomic oversights. As an example, since *A. alborosea* was not included in previous keys of the provincial flora, and no mention was made of its' resemblance to *A. rosea* in these keys, all specimens of *A. alborosea* would be identified as *A. rosea*. Most specimens which we examined were in fact misidentified as *A. rosea*. Second, in Alberta the species appears to be restricted to the Rocky Mountains where collecting outside the national parks is difficult because of inaccessibility. There is no reason for us to believe that the species recently migrated to these locations, nor is there sufficient evidence to suggest that the region within the national parks is floristically unique in comparison to the surrounding areas. The apparent concentration of these species in Banff and Jasper National Parks is a consequence of accessibility to the collectors as opposed to biological or historical phenomena.

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Range Extension for the Fourspine Stickleback, *Apeltes quadracus*, to Thunder Bay, Lake Superior

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An unusual range extension for the Fourspine Stickleback, *Apeltes quadracus*, is reported. Fifty-one specimens collected between August 1986 and October 1987 from Thunder Bay, Lake Superior, are approximately 2200 km from the nearest recorded population. Live-transport in the bilge of a sea-faring ship is considered the probable mechanism of distribution. Discussed is the ability of *Apeltes quadracus* to tolerate, survive and breed in waters of low conductivity.

Key Words: Fourspine Stickleback, *Apeltes quadracus*, Thunder Bay, Lake Superior, Batiscan River.

The Fourspine Stickleback, *Apeltes quadracus*, is known to occur on the Atlantic coast of North America, primarily in marine and brackish water and occasionally in fresh water. The shading on the distribution map in Bergeron and Brousseau (1983) indicated that *A. quadracus* is known to occur up in the St. Lawrence as far as Quebec City. Burgess and Lee (1978) reported a few isolated freshwater populations "far upstream in Hudson, Delaware and Susquehanna drainages." Livingstone (1953) recorded specimens "far removed from the sea" (approximately 30 km based on the distribution map). The population previously known to occur farthest from salt water is apparently located approximately 350 km from the sea in Harvey's Lake, Luzerne County, Pennsylvania, in the Susquehanna drainage (Cooper 1983).

This note reports on two range extensions for this species, one of which is unusual because it is approximately 2200 km via the Great Lakes from the nearest published record in Quebec City. The other record is from the Batiscan River approximately 85 km upstream from Quebec City and apparently the closest to the Thunder Bay record. Discussed are the mechanism of dispersal and the probability for the survival of the Fourspine Stickleback in Thunder Bay.

Methods and Results

A total of fifty-one specimens of *Apeltes quadracus*, were captured between 16 August 1986 and 6 October 1987 in Thunder Bay, Lake

Superior (See Table 1). Specimens from Neebing Marsh were collected at night with an electrofishing boat by B. A. R. Environmental in 1986 and Ecocern in 1987. They came from four areas from just north of the mouth of the Kaministiquia River to Keefer terminal at the original outlet of the Neebing River. Sticklebacks appeared to be most abundant over open sandy bottoms adjacent to short submerged macrophytes (R. Dalziel, personal communication). At the time of sampling in 1986 conductivity in the marsh was 140–150 uS/cm and the surface water temperature was approximately 18°C. Water clarity varied from clear to turbid. Two seine collections by W. Momot, C. Hartviksen and students at Lakehead University yielded nine specimens in 1987 (Table 1). One record (ROM 54909) extends the range of the species into Mission Marsh, 3 km south of the original captures in Neebing Marsh.

The *Apeltes quadracus* specimens captured in 1986 comprised 0.9% of 452 total individuals at the two sites combined which included 16 different species. *Apeltes quadracus* was one of 19 species captured by Ecocern in 1987 and specimens of it comprised 7% of 540 total individuals at four sites in Neebing Marsh.

The four individuals captured in 1986 had apparently been feeding recently. Gut contents of the two largest specimens consisted of amphipods (*Gammarus fasciatus*), mayfly nymphs (*Caenis* sp.) and a chironomid larva (*Endochironomus subtendens*) all invertebrates typically occurring in freshwater marshes and known to occur in the

TABLE 1. Captures of *Apeltes quadracus* in Thunder Bay

Location	Coordinates	Capture Date	Number	Total Length Range	Catalogue Number
Neebing Marsh (Site 1)	48°23'56"N;89°13'04"W	16 August 1986	2	30-53	ROM 51699
Neebing Marsh (Site 2)	48°24'14"N;89°13'05"W	19 August 1986	2	36-40	ROM 51698
Neebing Marsh (Site 1)	48°23'56"N;89°13'04"W	16 August 1987	20	25-46	ROM 54890
Neebing Marsh (Site 2)	48°24'14"N;89°13'05"W	22 August 1987	10	25-35	ROM 54889
Neebing Marsh (Site 3)	48°23'48"N;89°12'52"W	"	7	26-37	ROM 54888
Neebing Marsh (Site 4)	48°24'04"N;89°12'53"W	"	1	32	MNR 87-003
Kaministiquia R. mouth	48°23'30"N;89°13' W	7 September 1987	6	—	
Mission Marsh-McKellar R.	48°22' N;89°13' W	6 October 1987	3	40-43	ROM 54909

Thunder Bay area (William Morton, Ontario Ministry of Natural Resources, Fisheries Branch, personal communication).

In a search of the ROM ichthyology collection, a record of *A. quadracus* was discovered from fresh water approximately 85 km upriver from Quebec City. Six individuals, two males and four females (ROM 42180) were seined on 8 June 1981 by E. Holm and G. Coker in the Batiscan River, approximately 1 km up from its mouth in the St. Lawrence River, 46°31'16"N, 72°15'05"W. This record, to our knowledge, is the closest to the Thunder Bay records, the distance between them, via the Great Lakes, being approximately 2100 km.

We attempted to establish whether *A. quadracus* may have been captured near Thunder Bay in the past, but not recognized, by checking previous collection records. Neebing Marsh has been sampled on several occasions in the last five years. W. T. Momot, C. Hartviksen and students at Lakehead University sampled Neebing Marsh every year in September or October from 1983 to 1986. A few sticklebacks were captured and identified as *Culaea inconstans* (Brook Stickleback) and *Pungitius pungitius* (Ninespine Stickleback), the latter deposited at the ROM (ROM 50263). The Lakehead Region Conservation Authority sampled fishes in the marshes at Thunder Bay between 1982–1985 but also reported only *Culaea* and *Pungitius*. We confirmed the identification of one of the *Culaea* specimens.

Discussion

The number of specimens captured at six different sites indicates that *A. quadracus* is well established in the marshes of Thunder Bay. The fact that *Apeltes quadracus* has not been captured in regular yearly collections by Lakehead University or in the collections of the Lakehead

Region Conservation Authority suggests that it has been introduced relatively recently. Although there is over a seven-fold increase in numbers captured between 1986 and 1987, a large part of this increase may be caused by factors other than a growth in the Fourspine Stickleback population over one year. Netting was conducted by different persons who were aware of the previous *Apeltes quadracus* captures. Water levels were lower and therefore the same habitat could not be sampled. The percentage of all species of sticklebacks captured at all sites in Neebing Marsh increased dramatically from 3.3% of the total number of specimens in 1986 to 35% in 1987. However, the ratio of Fourspine Sticklebacks to other sticklebacks did not differ significantly (13.3% in 1986 vs. 19.8% in 1987).

Fourspine Sticklebacks are small and the colour pattern is similar to other stickleback species in the Great Lakes. Therefore, they may be missed when sorting quickly through small fish collections. When closely examined, *A. quadracus* can be easily recognized in having usually 2 large and 2–3 small dorsal spines, inclined alternately from one side to the other as are the spines of *P. pungitius*. This species, however, has more than 7 small spines. Other stickleback species have their spines vertical and not inclined to the left and right. Fourspine Sticklebacks have usually from three to five dorsal spines with four spines being the most common. Approximately thirty percent of the Thunder Bay specimens had five spines.

It has been suggested (Emery and Teleki 1978; Nepszy and Leach 1973) that unusual records in the Great Lakes of marine animals such as the European Flounder (*Platichthys flesus*) and the Chinese Mitten Crab (*Eriocheir sinensis*) have resulted from transport in the ballast tanks of ships. This method of dispersal is probable for *A. quadracus* and would explain the remoteness of the

Thunder Bay record from other populations. Ships can take in or expel ballast water anywhere along a ship's route from the Atlantic Ocean to northwestern Lake Superior. Strainers on bilge pipes may occasionally be broken to allow entry of larger fish, but nevertheless are normally coarse enough to allow passage of small minnows (M. O'Dowd, sailor for 25 years, presently with the Canadian Coast Guard, personal communication).

It is unlikely that the specimens come from a relict population since the distribution of Fourspine Sticklebacks is restricted to the Atlantic coast and they have not been captured during extensive sampling in the past. However, the possibility of an intentional introduction by man should not be discounted. *A. quadracus* is small and would make an interesting aquarium resident. Moreover, because of its short life span and rapid growth, it would make a useful experimental animal (Schwartz 1965). However, apparently no research at Lakehead University has involved the use of this stickleback (Don Barnes, Forestry Section, personal communication).

The Fourspine Stickleback is known to have the widest range of salinity tolerance of any North American stickleback (Nelson 1968). Under experimental circumstances it apparently preferred brackish water of 7 ppt (Audet et al. 1985) but there was some indication in the data that it did not avoid fresh water. There is a suggestion in the literature, however, (Blouw and Hagen 1981; Livingstone 1953) that *A. quadracus* cannot tolerate the low salt content of water in granitic areas and is present only in the soft rock regions of Nova Scotia.

We attempted to establish whether the Fourspine Stickleback could tolerate and breed in waters such as those in Neebing Marsh. Since salts constitute part of the electrolytes which can be measured as conductivity (Wetzel 1975), low conductivity can be used as an indication of a low level of salinity. We know of two populations of *A. quadracus* which breed at conductivities considerably less than that measured in Neebing Marsh. Conductivity measurements at the time of sampling and in September 1983 (J. Entwistle, Thunder Bay harbour marshes study summary report. Lakehead Region Conservation Authority, Thunder Bay, Ontario, 1986) indicate conductivity in the marsh ranges from 137 to 279 $\mu\text{S}/\text{cm}$. Coad and Power (1973) describe a population of Fourspine Sticklebacks in the Matamek River, Quebec, isolated between two waterfalls, which breeds at 10–20 $\mu\text{S}/\text{cm}$ (Power et al. 1973). *A. quadracus* were presumably breeding in the

Batiscan River since they contained ripe eggs or testes in advanced stages of development and, at the time of capture, they had "bright red fins". Conductivity was not measured at the time of sampling in the Batiscan River but measurements of conductivity throughout 1983, 10 km from the mouth (J. P. Gelinas, Ministère de l'Environnement at Trois Rivières, Quebec, personal communication) and estimates of conductivity of the near shore areas of the St. Lawrence near the mouth of the Batiscan River (Don McGirr, Surveys and Interpretive Services, Environment Canada, personal communication) suggest that the conductivity at the Batiscan site is somewhere between 22 to 107 $\mu\text{S}/\text{cm}$.

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First Collections of the Weed Shiner, *Notropis texanus*, in Canada

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Four collections of Weed Shiners (*Notropis texanus*) from the Winnipeg River, Manitoba, are the first of this species in Canada. The collections contained 345 specimens, including all size groups from under yearlings to mature adults of both sexes. It does not seem likely that introduction by man can account for this occurrence. Downstream dispersal from the Otter Tail River, Minnesota, into the Red River and Lake Winnipeg is probably blocked by unsuitable habitat. Upstream dispersal from Lake Winnipeg into the Winnipeg River is blocked by a series of rapids and falls in the Winnipeg River, some of which may have been barriers to upstream fish movement. The most likely entry route of Weed Shiners into the Hudson Bay drainage seems to be from Mississippi River headwaters to Rainy River headwaters in Minnesota, even though the species has not been collected in those areas.

Key Words: Weed Shiner, *Notropis texanus*, Hudson Bay drainage, Winnipeg River, zoogeography.

Weed Shiners (*Notropis texanus*) were collected on 20 September 1986, 11 August and 19 September 1987, from two locations on the south shore of the forebay of the Great Falls Dam on the Winnipeg River, Manitoba. This area is 435 km linear distance north-northeast of the Otter Tail River headwaters in west-central Minnesota, the nearest previously known occurrence of this species. Forty-seven under-yearling specimens were taken on 20 September 1986 and six on 11 August 1987 from a small bay about 200 m southeast of the upstream face of the dam (locality 1) by seining in water up to 75 cm deep. This site featured a silty mud substrate and well developed beds of submerged aquatic vegetation. On 11 August and 19 September 1987, 212 and 80 specimens respectively, were collected from the base of a peninsula extending from the south shore, 3.6 km south of the upstream face of the Great Falls Dam (locality 2).

These specimens were seined from water up to 1.2 m deep, which had thick beds of submerged aquatic vegetation growing on a mud substrate. Coordinates for locality 1 are 50°28' N, 96°00' W, and for locality 2 are 50°26' N, 96°00' W. The water at both locations was stained slightly brown, and varied from clear (during calm weather) to slightly turbid (when a strong onshore wind was blowing). The pH was 8.5 on all occasions, and water temperature ranged from 16.5°C at locality 1 on 20 September 1986 to 21°C at locality 2 on 11 August 1987. *N. texanus* occurs in clear, protected, weedy waters in lakes and larger rivers (Eddy and Underhill 1974). This is consistent with the

habitats from which the Great Falls specimens were collected.

Morphological Variation

The specimens from locality 1 were from 17.6 to 29.0 mm SL (Standard Length), while those from the locality 2 were from 18.5 to 39.1 mm SL (Figure 1). Specimens over 30 mm SL from locality 2 had enlarged gonads, and both sexes were present in the collections. Ten specimens collected from locality 1 on 20 September 1986 and 11 specimens collected from locality 2 on 11 August 1987, are deposited in the Royal Ontario Museum, with catalogue numbers 51886 and 52608 respectively. All the other *N. texanus* specimens are in the fish collection of the Department of Zoology, University of Manitoba.

Table 1 gives morphometric, meristic and pigmentation characters of the Winnipeg River *N. texanus*. It was necessary to stain the locality 1 specimens with alizarin in a two percent potassium hydroxide solution in order to increase visibility of fin rays and pharyngeal teeth. Counts and measurements were taken in conformity with the definitions in Hubbs and Lagler (1958).

The Manitoba specimens agree with the descriptions of *N. texanus* given by Eddy and Underhill (1974) and Becker (1983). *Notropis texanus* is similar to both *N. heterodon* (the Blackchin Shiner) and *N. heterolepis* (Blacknose Shiner), the only other *Notropis* species in Manitoba with a lateral stripe extending onto the head and across the snout. It is also superficially similar to *N. hudsonius* (Spottail Shiner) and

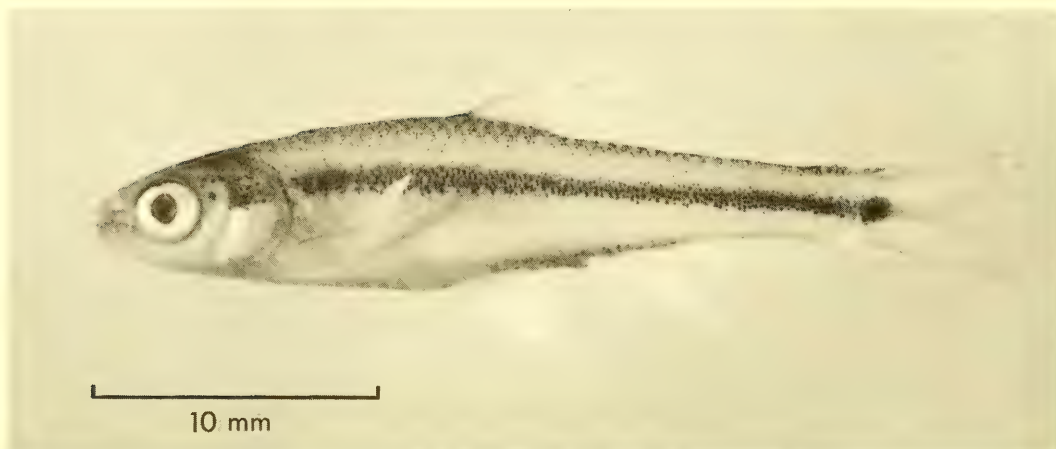


FIGURE 1. Left side of a 29-mm specimen of the Weed Shiner, *Notropis texanus*, collected at locality 1 on 20 September 1986.

Pimephales notatus (Bluntnose Minnow). All of these species occur in the Winnipeg River watershed in Manitoba, but only two, *N. hudsonius* and *N. heterolepis*, have been collected as far or further downstream than the Great Falls Dam where *N. texanus* was found. *N. blennioides* (River Shiner) resembles *N. texanus* in morphometry and meristic features, but lacks the strong lateral stripe. It is unknown from the Winnipeg River watershed in Manitoba, and is common in Manitoba only in the Red River mainstream.

Notropis texanus is distinguishable from all of these species by the following combination of characters: 1) two rows of pharyngeal teeth, with 2, 4-4, 2 the modal count; 2) anal ray number strongly modal at 7; 3) lower jaw included within the upper jaw; 4) upper jaw not projecting beyond the tip of the snout; 5) mouth reaching anterior margin of the eye; 6) strong lateral stripe, well-developed on the head, with pigmentation of snout, upper and lower lips; and 7) a well-marked basicaudal black spot partially separate from the lateral stripe (Table 1).

Zoogeography

Notropis texanus is known from the Mississippi and St. Croix rivers in southeastern Minnesota, and from the Otter Tail River, a tributary of the Red River of the north, in west-central Minnesota (Swift *in* Lee et al. 1980; Eddy and Underhill 1974). It is not known from the Lake Superior watershed, Mississippi River headwaters, or anywhere in the Hudson Bay drainage other than the Otter Tail River. Hubbs and Greene (1928) reported Weed

Shiners in the St. Croix River upstream from Taylor's Falls, but Eddy and Underhill (1974) reported no evidence of the species above Taylor's Falls in 20 years of sampling since then, and suggest that the range of *N. texanus* is decreasing in the Upper Mississippi watershed. Becker (1983) states that the range of the Weed Shiner is also decreasing in Wisconsin.

Transport by man does not seem likely as a source for the Great Falls Weed Shiners. Their adult size, between 50 and 60 mm (Swift *in* Lee et al. 1980), is somewhat smaller than preferred bait minnow size. Many *Notropis* species do not survive well in a bait bucket. Eddy and Underhill (1974) note that *N. texanus* is not common in Minnesota, and Becker (1983) states that the Weed Shiner in Wisconsin is too rare to be of any significance as either a forage or bait fish. The distance between the Otter Tail River and Great Falls would further make transport by man unlikely.

If the means of entry of Weed Shiners into Manitoba was natural, a downstream dispersal in the Red River from the Otter Tail River may not have been the source. The Great Falls localities lie above four rapids on the Winnipeg River, 29.3 m in elevation above the surface of Lake Winnipeg. Before construction of the Pine Falls and Great Falls Dams, the site would have been about 1 m lower than its present elevation. Great Falls (then known as Du Bonnet Falls) accounted for 16.36 m of this in a series of five drops, from 1.34 to 5.42 m in height (Johnston 1915). Upstream movement through Du Bonnet Falls of a 5-cm minnow adapted to weedy still water seems improbable.

TABLE 1. Observed values of some meristic, proportional and pigmentation characters for Winnipeg River *Notropis texanus*. All characters except lateral line scale counts and pigmentation were taken from the 47 specimens collected at locality 1 on 20 September, 1986. Lateral line scale counts were taken from 20 specimens, all over 30 mm SL, collected at locality 2 on 11 August, 1987. Numbers in parentheses are numbers of specimens having stated value. Pigmentation was noted on all specimens.

Character		Observed values
Pharyngeal tooth formula		2, 4-4, 2 (39)
		1, 4-4, 2 (2)
		1, 4-4, 1 (2)
		0, 4-4, 2 (1)
Anal rays		7 (46)
		6 (1)
Lateral line scales		37 (3)
		36 (8)
		35 (6)
		34 (3)
Anterior tip of upper lip		Below tip of snout
Mouth		Oblique, reaching below anterior margin of eye
Lateral stripe	On head	Not on iris, narrow and weak on snout, present on upper lip and tip of lower lip.
	On body	Uniform band, unmarked by darker edging on scale pockets. Dark pigment spots around lateral line pores anteriorly.
Basicaudal black spot		Distinct and partially separate from lateral stripe. Slightly wider than lateral stripe.
Dark edging of dorsal scale pockets		Scale pockets for first row above dorsal edge of lateral stripe lack dark edging. Dark edging begins in second row, making diamond-shaped pattern over back.

Additional evidence against downstream dispersal of *N. texanus* in the Red River is provided by comparison of the distributions of *N. texanus* and *Notropis heterodon*, which occur in similar habitats. Both species occur in the Mississippi River in southeastern Minnesota, but *N. heterodon* extends further upstream, occurring in Mississippi River headwaters upstream from

Bemidji, Minnesota. In the Red River watershed, both species occur in the Otter Tail River watershed, but *N. heterodon* also occurs in the Red Lake River watershed, the next drainage to the north of the Otter Tail River watershed. Both are restricted to clear lakes and streams in the upper reaches of these watersheds and do not occur on the Red River Plain (Eddy and Underhill 1974). The range of both is decreasing in Minnesota, apparently due to loss of clear, quiet, weedy habitat due to siltation (Eddy and Underhill 1974).

In Manitoba, neither *N. texanus* nor *N. heterodon* are found in the Red River watershed, even though both the Roseau River and Rat River contain significant areas of apparently suitable habitat and pose no significant physical barriers to upstream dispersal. Both the Roseau and Rat Rivers, unlike the Winnipeg River, have been collected on numerous occasions, so it seems unlikely that *N. texanus* and/or *N. heterodon* would have been missed if they occurred there.

By contrast, both *N. texanus* and *N. heterodon* occur in the Winnipeg River in Manitoba. *N. heterodon* also occurs in the Lake of the Woods watershed, in Falcon Lake, Manitoba (49°41' N; 95°19' W) and it has been found farther upstream in the Rainy River watershed in Quetico Park, Ontario (Crossman and McAllister 1986). In Manitoba, *N. heterodon* has disjunct occurrences in the Lake Dauphin watershed (Babaluk and Harbicht 1984), spring fed oxbow lakes on the Assiniboine River, west of the Manitoba Escarpment and in one tributary of the Souris River, near its confluence with the Assiniboine River (Stewart et al. 1985).

These distributions, and the physical barriers to upstream dispersal into the Winnipeg River from Lake Winnipeg, further suggest that neither *N. texanus* nor *N. heterodon* has achieved its present Canadian distribution by downstream dispersal in the Red River. The distribution of *N. heterodon* suggests transfer from Mississippi River headwaters to Rainy River headwaters in Minnesota and subsequent downstream dispersal in the Rainy River-Winnipeg River system. Because of the similar habitat requirements, this route also seems to be the most plausible one for *N. texanus*, even though its present distribution does not include Mississippi River headwaters or the Rainy River watershed.

The absence of *N. heterodon* from the Red River watershed in Manitoba, and from the Assiniboine River watershed east of the Manitoba Escarpment suggests as well that the westward dispersal of this species in Manitoba

took place through the Manitoba Great Lakes, with transfer to the Assiniboine River watershed occurring west of the Manitoba Escarpment via headwaters of the Lake Dauphin and Assiniboine River watersheds, probably in the Riding Mountain National Park area.

Four predictions based on these hypotheses may be tested. First, both *N. texanus* and *N. heterodon* should be found in additional areas of the Winnipeg/Rainy River system. Second, *N. texanus* may still be found in Mississippi River and/or Rainy River headwaters in Minnesota. Third, *N. heterodon* should eventually be found in the Interlake region of Manitoba, most likely in the Dauphin River/Lake St. Martin/Fairford River watershed. Fourth, continued effort should fail to produce either *N. texanus* or *N. heterodon* from the Red River watershed in Manitoba and from the Assiniboine River watershed east of the Manitoba Escarpment.

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Demographic Changes of the Eastern Chipmunk, *Tamias striatus*, with Supplemental Food

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Gregory, Michael J., Michael J. Lacki, and P. Kelly Williams. 1988. Demographic changes of the Eastern Chipmunk, *Tamias striatus*, with supplemental food. *Canadian Field-Naturalist* 102(4): 661-665.

From May 1977 through May 1979, demographic patterns of Eastern Chipmunks, *Tamias striatus*, were studied by use of live trapping and food supplementation experiments. Data on population size, recruitment, emigration, lactation rates, and overwinter survival were collected from three populations, each receiving a different schedule of food supplementation. Numbers of females were greater in summer for populations with supplemental food than populations without a food supplement. Recruitment of females into the populations increased with food supplementation, but the predominant age of recruits differed across sites. Overwinter survival was greater for females on food-supplemented sites than females on sites without added food, but only during one of the two winters studied. Lactation rates of adult females were not affected by food supplementation. No changes in demographic characteristics of male chipmunks with food supplementation were observed; however, males appeared more likely to emigrate from sites than did females regardless of the presence of added food. The available data suggest that different mechanisms may regulate the numbers of males and females in populations of Eastern Chipmunks, with the numbers of males controlled by agonistic behavior and the numbers of females limited by the size of the food resource base.

Key Words: Eastern Chipmunk, *Tamias striatus*, supplemental food, recruitment, survival, Ohio.

Demographic responses to food supplementation have been examined in several naturally occurring populations of ground-dwelling sciurids. Dunford (1977) observed populations of Round-tailed Ground Squirrels, *Spermophilus tereticaudus*, and found that dispersal of juvenile males was inhibited when added food was provided. Studies of Columbian Ground Squirrels, *S. columbianus*, have shown several responses to food supplementation, including increased immigration of females, enhanced juvenile survival, and greater reproductive outputs by resident females (Dobson and Kjelgaard 1985a; 1985b). Sullivan et al. (1983) reported results of a food supplementation experiment on Townsend Chipmunks, *Eutamias townsendii*, since reclassified in the genus *Tamias* (Levenson et al. 1985). Among the changes observed by Sullivan and co-workers were increased population size, faster growth rates of juveniles, and higher juvenile survival.

The Eastern Chipmunk, *T. striatus*, is a common mammal of forest communities throughout much of eastern North America (Hall and Kelson 1959). A number of food supplementation studies of Eastern Chipmunks have been reported (Mares et al. 1976; Mares et al. 1982; Lacki et al. 1984a; 1984b; Blackmore and Lishak 1985), but the only demographic property that has been examined is

density (Mares et al. 1976; Mares et al. 1982). Food supplementation experiments designed to evaluate other demographic processes in Eastern Chipmunks, such as reproductive outputs and survival rates, would permit a better understanding of how populations of this species are regulated. The objective of this study was to examine recruitment, overwinter survival, and reproduction in populations of Eastern Chipmunks provided with supplemental food.

Methods

This study was conducted from May 1977 to May 1979 in three deciduous woodlots of the Englewood Reserve, Englewood, Ohio (39° 52.7'N; 84° 18.2'W). All sites were within 700 m of each other. A chipmunk population within each woodlot received a different schedule of food supplementation. Food was provided in the form of shelled corn distributed uniformly with a Cyclone seed spreader at a rate of 20 kg ha⁻¹ week⁻¹. One population (EE) received corn from 30 July to 6 November 1977 and from 5 May to 12 October 1978. A second population (CE) was supplemented with corn from 12 May to 12 October 1978, and a third population (EC) from 7 July to 10 August 1977. Populations are designated as EE, CE, and EC according to their particular schedule of food supplementation, E

and C referring to whether a population was experimentally fed or left as a control in a particular year, respectively.

Justification for the brief period of food supplementation provided to the EC population in 1977 was presented by Lacki et al. (1984b). Their paper reported on home range size of Eastern Chipmunks before, during, and after food supplementation. The start of supplemental feeding at the EE site in 1977 was delayed due to difficulty in locating a third chipmunk population of suitable size. The remaining supplementation schedules covered the length of the active season for chipmunks in southern Ohio, from the appearance of spring-born juveniles to the onset of autumn torpor (Yahner and Svendsen 1978). Vegetation and site characteristics have been described by Gregory (1979).

Chipmunks were captured using live traps constructed of 6 by 30-cm polyvinylchloride pipe. A square grid was established at each site with traps spaced 20 m apart. The EE grid covered 2.56 ha within a 3.5-ha woodlot, whereas the other two grids covered 11.96 ha each, within woodlots of 8 (CE) and 14 ha (EC) in size. Traps were opened between 0700 and 0900 h and baited with sunflower seeds. Traps were set on an average of three days per week from 31 May to 20 October 1977, 1 April to 4 November 1978, and 23 May to 29 May 1979, except for the EE grid where traps were not in place until 27 June 1977.

Age, sex, body mass, and reproductive condition were recorded at each capture. Chipmunks were ear-tagged for identification with Monel #1 fingerling tags. An individual was classified as a juvenile if its weight at first capture was less than 95 g. This cut-off was used with unknown-age animals because all animals known to be adults were always heavier than 95 g. Lactation rates, defined as the proportion of adult females lactating, were calculated for both spring and summer breeding seasons.

Chipmunk population sizes were computed as the minimum number of animals known to be alive (MNKA). This method produced values for all time periods when chipmunks were captured, even during mid-summer lulls when fewer animals were active. A chipmunk was considered a resident if it was recorded on a site for at least two consecutive biweekly intervals. The remaining individuals were classified as non-residents in order to evaluate recruitment, newborns and immigrants combined into the population.

Overwinter survival was calculated as the proportion of chipmunks captured at least once on a site between September and November that were recorded alive the following year. Emigration of

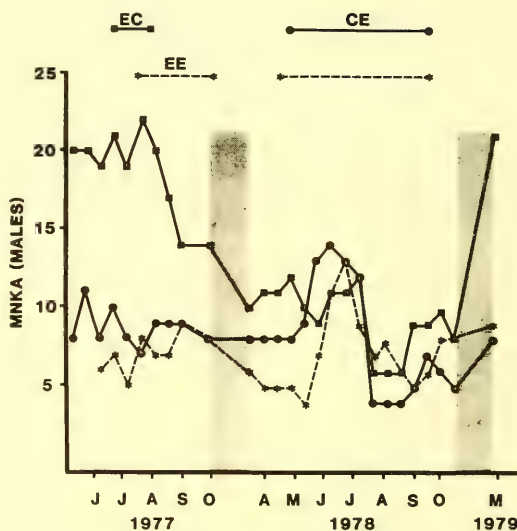


FIGURE 1. Population sizes as the minimum number known to be alive (MNKA) for male chipmunks, all ages combined. The horizontal lines labeled EE, CE, and EC indicate the time frames that food was added to these sites. Shaded bars represent overwinter periods where no trapping activity was conducted.

chipmunks from two of the populations was obtained with a pre-existing grid of No. 202 Tomahawk live traps, used for the study of gray squirrels, distributed at 40-m intervals throughout the woodlots enclosing the CE and EC grids. Tagged chipmunks trapped on these pre-existing grids outside of the study sites were recorded from 17 August to 27 August 1977 and from 29 July to 4 August 1978. These two intervals coincided with the trapping dates for the gray squirrel study.

Statistical tests were designed to compare populations within years, because the lengths of supplementation differed between years. Recruitment was evaluated for association with sex, age, site, and time using log-linear analysis (BMDP P4F; Dixon 1981). Overwinter survival and lactation rates were evaluated with Chi-square tests (Daniel 1974). Data collected in 1977 were combined for analysis into pre-supplementation, supplementation, and post-supplementation intervals, with the EE population effectively not having a post-supplementation interval, since supplementation on this site continued into autumn. Data for 1978 were grouped into biweekly intervals. An alpha level of 0.05 was used to determine significance.

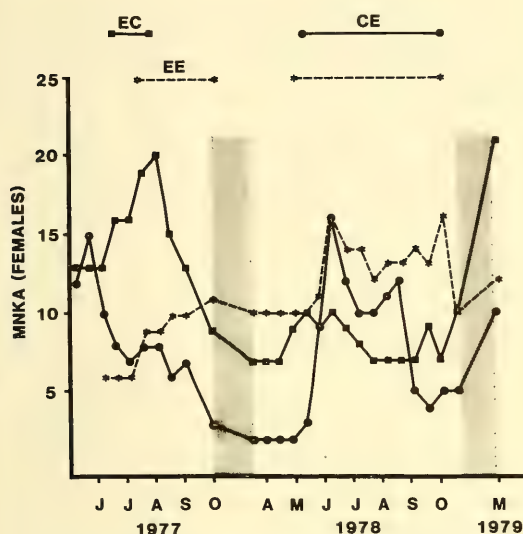


FIGURE 2. Population sizes as the minimum number known to be alive (MNKA) for female chipmunks, all ages combined. See Figure 1 for an explanation of symbols.

Results

Numbers of male chipmunks did not change in response to food supplementation in any of the populations examined (Figure 1). Initially, the numbers of males at the EC site were double the numbers at the CE and EE sites. The number of males at the EC site declined during August and September 1977 despite food supplementation in July and August. Numbers of males on the CE and EE sites fluctuated less than on the EC site. Increases in the numbers of males on the CE and EE sites occurred in 1978, but the increases were temporary and represented the emergence of spring-born juveniles and not a response to food supplementation.

The number of female chipmunks increased on all sites when provided with supplemental food (Figure 2). The increased number of females on food-supplemented sites was sustained for longer periods of time when food supplementation was extended into autumn. In years when populations were not provided with added food, numbers of females either decreased or increased slightly due to the emergence of juveniles.

Peaks in the number of juvenile chipmunks captured for the first time demonstrated two breeding seasons in 1978 for all three populations studied (Figure 3). The absence of late summer peaks in 1977 for new juveniles at the EC and CE sites suggested poor reproductive success. Examina-

tions of adult females in 1977 produced only one clear case of pregnancy in each population during that summer.

The number of females lactating during the spring reproductive season differed among populations in 1978 ($\chi^2 = 8.50$, d.f. = 2, $p < 0.05$), with a larger proportion of females lactating at the EE site than the other two sites (Table 1). Numbers of females lactating during the summer reproductive bout also varied among populations ($\chi^2 = 6.07$, d.f. = 2, $p < 0.05$), with the CE and EC populations having a greater proportion of lactating females than the EE population. Overall, reproductive success of chipmunks in 1978 was greater than in 1977, as evidenced by numbers of both lactating females and juveniles captured (Figure 3). These responses occurred in all populations and, therefore, could not be attributed to food supplementation.

Analysis of recruitment into the populations for 1977 produced a model with a site by time (pre-supplementation, supplementation, post-supplementation) interaction ($\chi^2 = 8.37$, d.f. = 2, $p < 0.05$). The EC population had significantly more

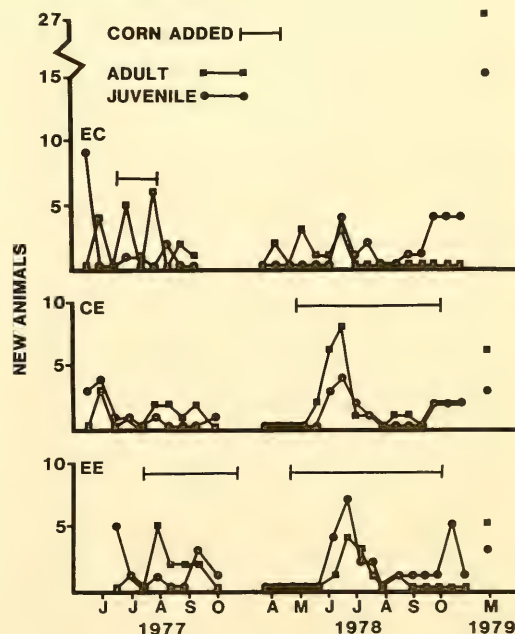


FIGURE 3. The number of animals captured for the first time, or new animals, following completion of the initial trapping period in 1977. Data for adults and juveniles are presented separately. The horizontal lines labeled EC, CE, and EE indicate the time frames that food (corn) was added to these sites.

TABLE 1. Proportion of adult female chipmunks lactating during spring and summer breeding seasons, 1978.

Season	Site	Number	Lactation Rate (%)
Spring	EE	8	87.5
	CE	2	0
	EC	8	25.0
Summer	EE	17	47.0
	CE	12	83.3
	EC	8	87.5

non-residents during the feeding period than the remaining populations. A three-factor model that included sex, site, and age was obtained for recruitment in 1978 ($\chi^2 = 8.30$, d.f. = 2, $p < 0.05$). This was interpreted as each sex class having a different site by age association. The food-supplemented populations (CE and EE) attracted more non-resident females than the control population (EC), but the age of the females entering these populations differed. Juvenile females were more abundant on the EE site, whereas numbers of adult females increased on the CE site.

All of the 14 chipmunks recorded as having moved off the study sites were males. We felt justified in classifying these animals as emigrants, because none of them were ever recorded as having moved back on the grid area. To evaluate losses from the populations, the numbers of animals never captured again were compiled (Figure 4). These data suggest the loss of large numbers of males during July 1978, and peaks of loss occurred on all sites regardless of the presence of supplemental food.

Overwinter survival from 1977 to 1978 was significantly different among populations for females ($\chi^2 = 8.81$, d.f. = 2, $p < 0.05$), but not for males ($\chi^2 = 0.32$, d.f. = 2, $p > 0.05$). Female survival was greatest in the EE population and lowest in the CE population (Table 2). There were no differences in overwinter survival among populations from 1978 to 1979 for either females ($\chi^2 = 3.64$, d.f. = 2, $p > 0.05$) or males ($\chi^2 = 0.14$, d.f. = 2, $p > 0.05$).

Discussion

Fordham (1971) proposed separate regulating mechanisms for the numbers of males and females in populations of the Deer Mouse, *Peromyscus maniculatus*, based on experimental tests using supplemental food. He suggested that densities of males are controlled by behavioral mechanisms operating during the breeding season, whereas the numbers of females are determined by food availability. Fairbairn's (1977) observations of Deer Mice concurred with Fordham's hypothesis, with

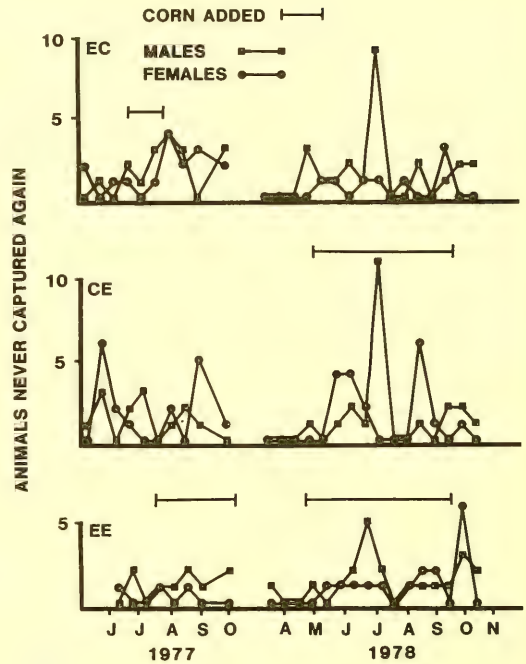


FIGURE 4. The number of animals never captured again. Each point represents the number of males or females of all age classes captured during the indicated period, that were never recaptured afterwards. See Figure 3 for an explanation of symbols.

dispersal and mortality being the ultimate factors determining numbers of males and females respectively.

Our findings suggest that different mechanisms may regulate the numbers of males and females in populations of Eastern Chipmunks. We observed demographic responses to supplemental food by female chipmunks but not males. The loss of large numbers of males from all populations in 1978 could not be directly attributed to food availability or any other environmental variable and was more likely a response to agonistic behavior of breeding adults (Wolfe 1966). The absence of substantial losses of males in 1977 from the populations we studied, coupled with evidence for minimal summer breeding efforts during that year and thus limited recruitment of new males, lends credence to such an explanation. A prolonged drought with high temperatures through May and June (Gregory 1979) was probably the reason for the absence of a summer breeding season in 1977.

A study on populations of Townsend Chipmunks (Sullivan et al. 1983) found food supplementation

TABLE 2. Rates of overnight survival for male and female chipmunks, all ages combined.

Years	Sex	Site	Number	Survival Rate (%)
1977-78	Male	EE	12	58.3
		CE	10	70.0
		EC	16	62.5
	Female	EE	11	90.9
		CE	8	25.0
		EC	14	50.0
1978-79	Male	EE	14	42.8
		CE	9	44.4
		EC	12	50.0
	Female	EE	20	50.0
		CE	14	35.7
		EC	14	71.4

influenced both males and females, so that demographic patterns may not be consistent within the genus *Tamias*. Our experimental design was not without limitations, however. We examined only three populations and our replication was based on temporal controls. Potential sources of error with this approach include carry-over or lag effects that may have prevented the EC site from being a true "control" or untreated site during the second year (1978). Error of this type should theoretically have made detection of responses to food supplementation in 1978 less likely, because the untreated population was still experiencing effects of supplementation from the previous summer. This would lead to a more conservative approach due to the reduction in Type I error. No sites remained untreated in both years, so yearly variation was also not completely accounted for in our design; thus, these results must be viewed with caution, especially in light of the density responses of male Eastern Chipmunks to supplementation observed by Mares et al. (1982). Clearly, before Fordham's hypothesis can be adopted, more testing of additional small mammal species is required.

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A Comparison of Avian and Mammalian Faunas at Lake Hazen, Northwest Territories, in 1961–62 and 1981–82

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Gould, Joyce. 1988. A Comparison of avian and mammalian faunas at Lake Hazen, Northwest Territories, in 1961–62 and 1981–82. *Canadian Field Naturalist* 102(4): 666–670.

A comparison of the birds and mammals observed in the vicinity of the Defence Research Board camp at Lake Hazen, Northwest Territories, in 1981 and 1982 to those recorded by Savile and Oliver in 1961 and 1962 showed similar species composition, although numbers of individuals and breeding success differed from year to year. This difference emphasizes the need for caution when making judgements regarding population status based on the observations of one year.

Key Words: Lake Hazen, Ellesmere Island Park Reserve, High Arctic, mammals, birds, Northwest Territories.

The fauna of the Lake Hazen area is relatively well-documented in comparison to most other sites in the High Arctic. Incidental observations of the fauna were initiated with the establishment of the Defence Research Board camp in 1957–1958 during the International Geophysical Year (Tener 1959). Savile and Oliver (1964) reported on their observations of birds and mammals in 1961 and 1962, and Nettleship and Maher (1973) described the avifauna of the area. There were several population studies including those on Muskoxen (Tener 1965), Long-tailed Jaeger (Maher 1970), Turnstones (Nettleship 1973) and Knots (Nettleship 1968, 1974).

Incidental observations of birds and mammals were made in 1981 and 1982 while I was based at Lake Hazen camp conducting botanical studies. The objectives were to document the birds and mammals occurring within the study area and to compare observations of the fauna twenty years after the account of Savile and Oliver (1964).

Lake Hazen lies within the Northern Ellesmere Island Park Reserve and it is hoped that these observations will assist in the park planning process.

Study Area

Base was established at Hazen camp on the northwest shore of Lake Hazen at 81°49'N; 71°18'W (Figure 1). It encompassed an area bounded by the shore of Lake Hazen, the summit of McGill Mountain,¹ Blister Creek, and the Snow Goose River, an area of 25 km². Elevation ranged from 160 m ASL (above sea level) at lakeshore to 1040 m ASL at the summit of McGill Mountain.

McGill Mountain consists primarily of scree and is poorly vegetated. Meadows dominated by *Dryas integrifolia* (Mountain Avens) – *Carex nardina* *Kobresia myosuroides* (sedges) cover the lowland, with *Cassiope tetragona* (Arctic White-heather) and/or *Dryas integrifolia* in late-lying snowmelt areas and sparsely vegetated graminoid meadows on the dry clays. Sedge meadows dominated by *Carex aquatilis-stans* (sedge) – *Eriophorum angustifolium-triste* (cotton grass) and *E. scheuchzeri* occur in the valleys situated between the ridges at the base of McGill Mountain. More complete descriptions of the vegetation were provided by Savile (1964) and Gould (1985).

There are at least four permanent ponds in the study area in addition to several intermittent ponds.

Methods

Portions of the study area were traversed daily during the period of 21 June to 3 August 1981 and 26 June to 9 August 1982, except for 20–25 July in 1982. Bird and mammal observations, including numbers of each species, were recorded daily. Notes of faunal activity in each of the plant communities were also made.

Results and Discussion

BIRDS

Red-throated Loon, *Gavia stellata*

Two pairs of Red-throated Loons nested in the study area in 1981 and 1982. One pair nested on an island in a small pond located approximately 3 km west of camp (Skeleton Lake – Pond 34) in both years. Young hatched 21–25 July 1981 (one chick) and 16–27 July 1982 (two chicks).

A second pair of loons nested on other ponds 4 km northwest of camp (Pond 30 in 1981; Pond 12

¹Place names follow those outlined in Savile and Oliver (1964).

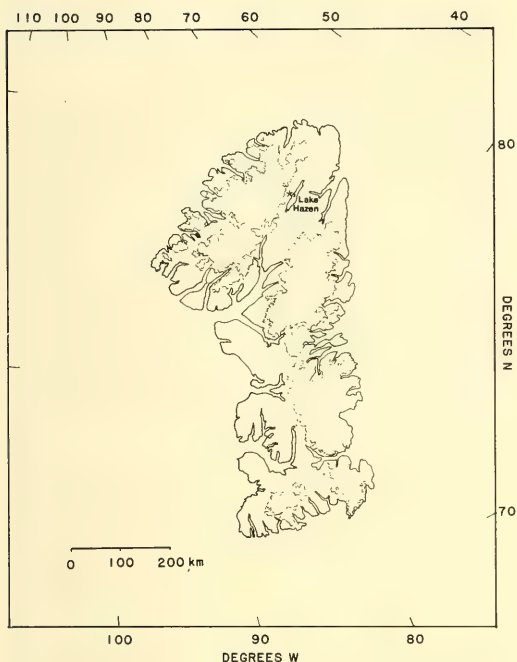


FIGURE 1. Location of the Lake Hazen study area on Ellesmere Island.

in 1982). Eggs were laid, but as of 3 August 1981 and 9 August 1982, hatching had not occurred.

This same trend was observed by Savile and Oliver, with successful fledging occurring on Pond 34 in 1961, 1962 and 1963 (D. R. Oliver, personal communication to D. B. O. Savile, 1982) and delayed hatching on Pond 30 in 1962. This delayed nesting was attributed to the delayed ice-melt and early freeze-up of this pond (Savile and Oliver 1964).

Skeleton Lake (Pond 34) may be the most northerly successful nesting site for Red-throated Loons in Canada (D. B. O. Savile, personal communication 1982). Red-throated Loons have been recorded at Alert (82°30'N; 62°29'W), but although a nest with two eggs was found, young were not observed even as late as 22 August 1951 (MacDonald 1953).

Snow Goose, *Anser caerulescens*

There was no evidence of breeding at Lake Hazen camp in 1981 or 1982, although several individuals were observed on two occasions in 1981 and on one occasion in 1982. Savile and Oliver (1964) documented successful breeding of Snow Geese in the camp area in 1962.

Brant, *Branta bernicla*

One individual was observed flying over Lake Hazen on 8 July 1982. The species was not recorded in 1961, 1962 or 1981.

King Eider, *Somateria spectabilis*

A non-breeding pair was observed in 1981. In 1982, a nest with three eggs was found on 29 June but the entire nest was raided, presumably by fox, sometime before 6 July. Savile and Oliver (1964) noted non-breeding birds in 1961 and successful fledging of four young in 1962.

Oldsquaw, *Clangula hyemalis*

At least five individuals were observed in 1981, although no young were seen. In 1982, there were two nesting pairs, and a total of seven young fledged.

Oldsquaws were observed with young in 1962 (Savile and Oliver 1964).

Gyr Falcon, *Falco rusticolus*

One Gyr Falcon was seen on 16 July 1982 when it was pursued by three Long-tailed Jaegers. One was seen again on 4 August. The species was not observed in 1961 or 1962.

Rock Ptarmigan, *Lagopus mutus*

At least two pairs bred in the study area in 1981, with a total of eleven young being produced. There was a minimum of three breeding pairs in 1982 with groups of four, six and eight chicks.

Successful breeding was also documented in 1962 (Savile and Oliver 1964).

Sandhill Crane, *Grus canadensis*

Tracks were observed by Savile and Oliver in 1962 but no evidence of this species was obtained in 1981 or 1982.

Ruddy Turnstone, *Arenaria interpres*

Ruddy Turnstone was the most abundant bird of the lowland in the study area in 1981 and 1982, but estimates of numbers were not obtained. Nettleship (1973) estimated the population density to be 3 pairs/km².

One nest was found in the *Dryas* - sedge meadow along Skeleton Creek in 1981 and one chick was observed. Two nests were found in 1982, both on hummocks of *Dryas integrifolia*. One nest produced three young, the other, one. Hatching occurred on 2 July 1981 and 12 July 1982. By 13 July 1982, the Turnstones were flocking; 31 were observed near the shore of Lake Hazen. This flock consisted entirely of adults. Another flock of seven immatures was seen on 2 August.

These numbers and dates are in close agreement with those recorded by Savile and Oliver (1964) and Nettleship (1973).

Red Knot, Calidris cahutus

Red Knot was a common breeding bird in the study area, although over the span of two summers only one nest with four eggs was found (12 July, 1982). Nettleship (1974) estimated the population density to be 1 pair/km².

Successful breeding was documented in 1961 and 1962 (Savile and Oliver 1964), 1966 (Nettleship 1968, 1974), 1981 and 1982.

Sanderling, Calidris alba

There was no evidence of breeding in 1981 and 1982, although individuals were noted in early August in both years. Breeding was documented, however, in 1962 (Savile and Oliver 1964).

Baird's Sandpiper, Calidris bairdii

This species was confirmed breeding in 1961 but no evidence of the species was obtained in 1981 or 1982.

Long-tailed Jaeger, Stercorarius longicaudus

Two pairs nested in the *Dryas* - sedge meadows of the lowland of the study area in 1981. Hatching occurred on 4 July and 17 July. There was a single pair nesting in 1982. One egg was laid but this was removed by an Arctic Fox (*Alopex lagopus*) on 5 July. Savile and Oliver (1964) noted a lack of breeding success in 1961 but noted six pairs in 1962. Maher (1970) examined the breeding ecology of the Long-tailed Jaeger at Lake Hazen and noted 0 to 6 pairs between 1961 and 1968. He speculated that breeding success was correlated with the lemming population in the area. Lemmings were not common in either 1981 or 1982. Savile and Oliver (1964) suggested that a late spring may be another factor determining breeding success at Lake Hazen. Temperatures at Lake Hazen were lower in 1982 than in 1981, and it was presumed that winter and spring of 1982 were severe, based on the low reproductive success of Arctic Hare (*Lepus arcticus*) and Muskoxen (*Ovibos moschatus*) and the presence of several carcasses of the latter.

Glaucous Gull, Larus hyperboreus

This species was seen in 1961, 1962 (Savile and Oliver 1964), 1981 and 1982 with no evidence of breeding.

Cliffs for nesting do not occur in the camp area, but are available in close proximity to it.

Arctic Tern, Sterna paradisaea

At Lake Hazen, the Arctic Tern nested on gravel beach ridges near the shore of the lake. One nest was found in 1981 and two in 1982, although one was abandoned. Hatching occurred late in the season, after 21 July 1981 and 31 July 1982.

Nesting was documented in both 1961 and 1962 by Savile and Oliver (1964).

Snowy Owl (Nyctea scandiaca)

The Snowy Owl is an irregular visitor to the Lake Hazen camp area. One was observed on several different occasions in 1982. It was first seen on 18 July, perched on a gravel outcrop near camp where it remained for approximately thirteen hours. An owl was then seen at intervals of about once every three days for the remainder of the field season.

The presence of the owl was often indicated by the alarm call of the jaegers. Both Ruddy Turnstones and Snow Buntings were seen feeding on the same outcrop as the perched owl.

Savile and Oliver (1964) noted one individual on several occasions in 1961.

The hummocky terrain necessary for nesting (Godfrey 1986) occurs in the camp area.

Common Raven, Corvus corax

One individual was observed flying over camp on 24 July 1981. There has been no other documentation of this species at Lake Hazen although MacMillan (1925) reported it near Alert at 83°40'N.

Lapland Longspur, Calcarius lapponicus

One female was seen on 28 June 1981 on an outcropping of sandstone near camp. Savile and Oliver (1964) recorded one male in both 1961 and 1962.

It is possible that this species is an irregular nesting bird at Lake Hazen but there is no evidence yet.

Snow Bunting, Plectrophenax nivalis

Snow Buntings were common at Lake Hazen, particularly on the scree slopes associated with McGill Mountain. A minimum of ten pairs nested in both years with the young first appearing on 8 July 1981 and 5 July 1982. By the end of July, the young had congregated around base camp on the shore of Lake Hazen.

Savile and Oliver (1964) estimated 25 nesting pairs in 1962.

Hoary Redpoll, Carduelis hornemanni

This species was not observed in 1981 or 1982, although it was a common breeder in 1962 with 12 pairs (Savile and Oliver 1964).

MAMMALS

Arctic Fox, Alopex lagopus groenlandicus

Adults were seen in the study area in 1962 (Savile and Oliver 1964), 1981 and 1982. Savile and Oliver (1964) observed two young at a den in 1962, but the

only evidence of breeding in 1981 or 1982 was that of an adult carrying a Red Knot which it had killed to an area of scree near McGill Mountain. It could not be ascertained if a den was nearby.

One abandoned den with 15 openings was located on a southeast-facing slope of one of the terraces at the base of McGill Mountain in 1982. The vegetation was lush compared to that of the adjoining slope, with high representation of *Alopecurus alpinus* (Foxtail) and *Arnica alpina* (Arnica), two species often associated with areas high in nitrogen content.

Foxes were frequently seen around camp and were observed raiding the nest of a Long-tailed Jaeger. Savile and Oliver (1964) noted that foxes were successfully scared off by Jaegers in 1961 and 1962.

Arctic Hare, *Lepus arcticus*

The population of Arctic Hares at Lake Hazen fluctuates greatly. Hares were abundant in 1981 — well in excess of 50 individuals — and young were very common. In 1982, only five adults and no young were seen.

Hares were not observed in 1961, and in 1962 a total of five adults was recorded (Savile and Oliver 1964).

Arctic Wolf, *Canis lupus arctos*

Arctic Wolves were seen intermittently during the summers of 1981 and 1982. In 1981, a group of three was observed on two different occasions and a group of four on one. They always approached camp from the southwest. In 1982, a group of six was seen at the beginning of the field season. Subsequent to this, one male frequented the area and on one occasion was observed scent marking around camp. It would follow people into the field, walking parallel to the group, stopping when the group did so, and at one point came within 7 m.

The wolves followed herds of Muskoxen moving through the study area, often appearing two to three days after the herds had moved through camp.

Wolves near camp were also recorded by Tener (1959) and Savile and Oliver (1964).

Collared Lemming, *Dicrostonyx groenlandicus*

As with Arctic Hare, the population of Collared Lemming fluctuates. Lemmings were scarce in 1961, 1981 and 1982, with no evidence of breeding. In 1962, Savile and Oliver (1964) reported several juveniles.

Ermine, *Mustela erminea arctica*

A small population probably exists in the study area, with one individual observed in *Dryas* hummocks 2 km southwest of camp in 1981. Savile and Oliver (1964) reported tracks.

Muskox, *Ovibos moschatus*

The sedge meadows at Lake Hazen have been documented as important foraging areas of Muskoxen during both the summer and winter months (Soper 1959; Tener 1965). In addition to sedges, *Salix arctica* (Arctic Willow) is also an important component of the diet and the *Dryas* — *Salix* communities of the lowland are also used as grazing areas (Tener 1965).

Herds of Muskoxen were observed feeding in both the sedge meadows and grass — *Salix* communities of the lowland in both 1981 and 1982. These herds ranged in size from 4 to 15 individuals with an occasional lone bull. There was little difference in herd size between the two years: in 1981 there were four calves; in 1982 there was only one. Winter pellets were abundant in the sedge meadows, indicating the importance of these meadows as winter habitat.

Five carcasses were seen in the study area in 1982, none in 1981. One of the carcasses had been scavenged; the other four were intact. However, one carcass was partially eaten three weeks later. The stomach contained the remains of partially digested *Salix arctica*. It is possible that a spring storm that would cover the vegetation in ice or hard-packed snow caused the starvation of some animals.

Peary Caribou, *Rangifer tarandus pearyi*

Peary Caribou were observed at Lake Hazen, although the study area is not large enough to support a resident population. Two females and two calves were observed in a sedge meadow at the base of McGill Mountain on 1 July 1981. In 1982, on two separate occasions, there were two males (one 4–5 years of age, one 2) in a meadow of *Cassiope tetragona* on the northeast side of McGill Mountain. Both animals were grazing on *Papaver lapponicum* (Arctic Poppy). There were a number of antlers in this meadow suggesting that it is frequented by Caribou.

Caribou were not seen in 1961 or 1962 (Savile and Oliver 1964).

Summary

The Lake Hazen camp area cannot support resident populations of larger mammals such as Arctic Wolf, Muskoxen and Peary Caribou. However, it does provide important feeding areas in both the summer and winter months. The sedge meadows that are so important as habitat for Muskoxen and Caribou are scarce on northern Ellesmere (Gould 1985) and, thus, those at Lake Hazen may represent critical habitat.

The smaller mammals may successfully raise young in favourable years. The same holds true for many of the bird species.

Comparison of the data from 1961–1962 to that of 1981–1982 shows many similarities in the composition of the fauna and it also stresses the fluctuations of these populations in a high arctic environment. It reinforces the view that judgements of population structure should not be based on one field season (Pruitt 1978).

The Lake Hazen camp areas provides habitat for what is likely the most northerly successful breeding site for Red-throated Loons. It also provides habitat for a population of Peary Caribou, a species designated as threatened in Canada (Committee on the Status of Endangered Wildlife in Canada 1986).

Many of the animals on northern Ellesmere Island are at their limits of tolerance, and stress, such as that imposed by humans, may have detrimental effects on population structure. Planning strategies for the newly established park reserve should consider this.

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White-tailed Deer, *Odocoileus virginianus*, Fecal Groups Relative to Vegetation Biomass and Quality in Maine

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Etchberger, Richard C., Rosemary Mazaika, and R. Terry Bowyer. 1988. White-tailed Deer, *Odocoileus virginianus*, fecal groups relative to vegetation biomass and quality in Maine. *Canadian Field-Naturalist* 102(4): 671-674.

Relationships between the location of White-tailed Deer, *Odocoileus virginianus*, fecal groups and the biomass and quality of adjacent vegetation were studied in a hay field near Unity, Maine, in November 1984. Dry weight biomass of vegetation (primarily *Phleum pratense* and *Trifolium* sp.) clipped from 0.25-m² plots adjacent to deer fecal groups ($\bar{x}$ = 5.1 g, SD = 1.6 g) was significantly higher than for random plots ($\bar{x}$ = 2.6 g, SD = 1.1 g). Crude protein content of vegetation near fecal groups ($\bar{x}$ = 20.9%, SD = 8.0%), however, was similar to vegetation at random locations ($\bar{x}$ = 20.6%, SD = 4.9%). Distance from the forest edge did not significantly affect biomass or protein content of vegetation. Location of White-tailed Deer fecal groups was a reliable indicator of greater forage biomass, and was likely related to the feeding activities of this ungulate.

Key Words: White-tailed Deer, *Odocoileus virginianus*, fecal groups, vegetation biomass, vegetation quality, Maine.

Although pellet group counts have been employed to estimate habitat use and population size for ungulates (Julander et al. 1963), reliability of such techniques continues to be debated. Strong relationships were reported between location of Mule Deer (*Odocoileus hemionus*) feces and occurrence and use of preferred foods (Anderson et al. 1972; Bowyer 1984; McCullough 1969). Nonetheless, others have cautioned against inferring habitat use by counting pellet groups (Collins and Urness 1981; Neff 1968). Collins and Urness (1979) reported significant differences between locations of pellet groups and distributions and activities of tame Wapiti (*Cervus elaphus*). Leopold et al. (1984), however, noted that problems with pellet group counts arose only in comparisons of absolute densities and habitat use, and suggested that relative magnitude of deer densities determined from pellet group transects provided reliable indices of use.

Murphy et al. (1985) documented the importance of agricultural lands and grasslands in the ecology of White-tailed Deer (*O. virginianus*) in Wisconsin, and Crawford (1982) pointed out the prominence of herbaceous species in the diet of these deer in Maine. Because of the value of agricultural areas to northern populations of deer, this habitat was selected to study relationships between fecal groups and deer forage. We hypothesized that if the location of fecal groups served as an index to foraging activities as reported

for Mule Deer, vegetation biomass or quality would be greater adjacent to fecal groups of White-tailed Deer than for random samples.

Study Area

Research was conducted in a 3-ha hay field near Unity, Waldo County, Maine (44° 36' N; 69° 23' W) at an elevation of 76 m. The field adjoined a deer wintering area that encompassed 3 km² of boreal forest. Topography of this area is low, rolling hills. The forest overstory is dominated by conifers including Balsam Fir (*Abies balsamea*), White Pine (*Pinus strobus*), and Northern White Cedar (*Thuja occidentalis*); northern hardwoods are scattered throughout the forest. Hay-field vegetation is dominated by Timothy Grass (*Phleum pratense*) and Clover (*Trifolium* sp.), generally < 15 cm tall. The population of deer was not estimated, but > 65 deer were observed in the hay field at one time. This population has increased in recent years because of a change in hunting regulations that substantially reduced the kill (Hodgman and Bowyer 1986). A more complete description of this area was provided by Hodgman and Bowyer (1985).

Methods

Data were collected weekly in November 1984 by clipping vegetation in 50 random 0.25-m² plots. Fresh fecal groups were located by walking along randomly placed 1-m wide transects that distributed

sampling effort across four sections of the field, each 25 by 300 m. An additional 50 vegetation sample plots adjacent to these fresh fecal groups also were clipped. Four 0.0625-m² plots were located 1.2 m from the center of a fecal group at the four cardinal compass points; all four plots were combined into a single sample (0.25 m²) that represented the vegetation surrounding each fecal group. Adequate sample sizes for random samples and those near fecal groups were assured by examining reduction of the variation in the mean as sample size increased (Kershaw 1964: 29). One random sample was lost during transportation from the field to the laboratory. Distance of each sample from the forest edge was measured and categorized as 0–25 m, 26–50 m, 51–75 m, or 76–110 m from cover. Vegetation samples were separated to remove dead or inorganic material, were oven dried at 50° C for 24 h and weighed to the nearest 0.01 g to obtain dry weight biomass.

Because the field was mowed in September, feeding site inspections such as those used by Mackie (1970) and Bowyer and Bleich (1984) to determine deer use of vegetation were not possible. Deer were observed feeding and defecating in the field, but because the population was hunted and extremely wary, attempts to quantify these parameters were unsuccessful. Deer were not observed bedding in the field, but evidence of beds was found in the forest around its periphery.

Crude protein content of vegetation was used as a measure of quality and determined from standard micro-Kjeldhal procedures (Horwitz 1975). Statistical analyses included the Kruskal-Wallis and Mann-Whitney *U*-tests (Siegel 1956).

Results

The Kruskal-Wallis test indicated no significant effects of distance from the forest edge on biomass of random samples (*P* = 0.13), biomass of samples adjacent to fecal groups (*P* = 0.14), crude protein content of random samples (*P* = 0.40), or crude protein content of samples adjacent to fecal groups (*P* = 0.33) [Table 1]. Consequently, samples from various distance categories were pooled for further analyses. The Mann-Whitney *U*-test showed a highly significant difference (*P* < 0.001) in dry weight biomass of vegetation between random samples and those near fecal groups, but no difference (*P* = 0.17) occurred between these same variables for crude protein content (Table 1).

Discussion

Maxima for dry weight biomass of vegetation samples adjacent to fecal groups were considerably larger than for random samples (Table 1). This pattern may have occurred because deer sought out rare and widely distributed areas of high vegetative biomass. Coefficients of variation for dry weight biomass of vegetation were larger for random samples (42%) than those near fecal groups (31%); this also would be expected if deer selected microhabitats with more vegetation.

Biomass of vegetation adjacent to White-tailed Deer fecal groups was nearly twice that of random samples (Table 1). Our results agree with those of McCullough (1969), and Anderson et al. (1972) for locations of Mule Deer feces relative to use and biomass of preferred forages. Differences in crude protein between random samples and those near fecal groups, however, were slight (Table 1) and

TABLE 1. Dry weight biomass and crude protein content of vegetation clipped from random plots and plots adjacent to White-tailed Deer fecal groups in a 3-ha hay field near Unity, Maine, November 1984.

Distance from Forest Edge (m)	N	Biomass (g/0.25 m ²)			% Crude Protein		
		$\bar{x}$	SD	Range	$\bar{x}$	SD	Range
RANDOM SAMPLES							
0-25	21	2.7	1.1	0.6-4.9	19.6	4.7	10.8-30.0
26-50	15	2.2	1.3	0.5-5.3	22.4	6.2	13.5-38.5
51-75	10	3.0	0.7	1.9-4.3	20.3	3.6	16.6-28.3
76-110	3	3.1	0.8	2.2-3.7	20.5	0.9	19.9-21.5
0-110	49	2.6	1.1	0.5-5.3	20.6	4.9	10.8-38.5
SAMPLES ADJACENT TO FECAL GROUPS							
0-25	21	5.2	1.8	2.0-8.0	22.4	9.5	14.8-54.5
26-50	16	5.2	1.3	2.9-8.2	21.5	8.8	15.9-51.7
51-75	10	5.4	1.3	3.5-7.4	18.3	1.6	15.1-20.2
76-110	3	2.9	0.9	2.0-3.7	16.6	1.5	15.3-18.3
0-110	50	5.1	1.6	2.0-8.2	20.9	8.0	14.8-54.5

may have resulted from relatively low variation in this parameter in the mowed hay field. The coefficient of variation for random samples of crude protein was only 24%. Additionally, deer probably selected the hay field as a desirable place in which to feed because of the uniformly high crude protein content of forbs and grasses that occurred there. Thus, crude protein of vegetation also may affect selection of foraging sites in other areas where this parameter is more variable.

White-tailed Deer defecated and presumably fed in areas of greater vegetation biomass within a single vegetative type. Direct measurements of feeding activities could not be made, but we suggest they may be inferred from our data on vegetation biomass. Thus, fecal groups were a reliable index to the occurrence of deer at sites with more forage in a Maine hay field.

Our results do not conform to the prediction by Collins and Urness (1979, 1981) that locations of fecal groups are unrelated to grazing activities of cervids. Our results may differ for two reasons. First, we sampled small areas around pellet groups within a single vegetative type, whereas they collected data on grazing activities in many different plant communities. The scale on which they sampled would not detect changes in grazing activities relative to the localized differences in vegetative biomass that we observed. Second, both their studies (Collins and Urness 1979, 1981) used a small number of tame animals. Whether these tame cervids fed and defecated in a manner representative of their wild counterparts is unknown. For instance, Bartmann and Alldredge (1982) reported that tame Mule Deer foraged differently from wild ones.

Williamson and Hirth (1985) reported variation in the selectivity of foraging by free-ranging deer as they ventured farther from escape cover, and Bowyer (1986) noted a decline in deer use of areas far from cover. Although not significant, we noted a decrease in biomass and crude protein content in vegetation adjacent to fecal groups farthest from the forest edge, a pattern not evident in random samples (Table 1). These results raise the possibility that fecal groups far from the edge of the field may be a poor indicator of sites with high biomass or protein content. Our sample sizes were too small to test for such a relationship, but this possibility warrants further investigation.

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Apparent Predation by Grey Seals, *Halichoerus grypus*, on Seabirds around Sable Island, Nova Scotia

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Lucas, Zoe, and Ian A. McLaren. 1988. Apparent predation by Grey Seals, *Halichoerus grypus*, on seabirds around Sable Island, Nova Scotia. *Canadian Field-Naturalist* 102(4): 675–678.

Existing information on predation by pinnipeds on seabirds is summarized. Conditions of beached corpses suggest that Grey Seals may kill numbers of procellariids and alcids, especially oiled ones, around Sable Island.

Key Words: Grey Seals, *Halichoerus grypus*, predation, seabirds, oiling, influenza.

We have been told by a number of colleagues and fishermen of incidents of Grey Seals, *Halichoerus grypus*, and Harbour Seals, *Phoca vitulina*, pursuing, capturing or apparently eating birds in Nova Scotia. Bird remains have not, as far as we know, been reported in stomachs of these two phocids from the province (Mansfield and Beck 1977; Boulva and McLaren 1979). Extensive predation on penguins by Leopard Seals, *Hydrurga leptonyx*, is well documented (review in Spellerberg 1975). Some bird predation has also been noted for a number of southern hemisphere otariids (Paulian 1964; Shaughnessy 1978; Boswell 1972; Crawley and Wilson 1974; Notman 1985). Among such species even casual predation might be more frequently observed because of the extensive mingling of birds and pinnipeds around colonies in the southern hemisphere. There are also scattered observations of birdcatching by northern pinnipeds, or bird remains in their stomachs. These include Steller Sea Lion, *Eumetopias jubatus* (Tikhomirov 1959), Northern Fur Seal, *Callorhinus ursinus* (McHugh 1952; Spalding 1964), Ringed Seal, *Phoca hispida* (Macdonald 1954), Spotted Seal, *Phoca largha* (Tikhomirov 1970), Harbour Seal on the Canadian west coast (Spalding 1964), and Grey Seal in Britain (e.g., Hamilton 1946; Armstrong 1972; Rae 1973; Del-Nevo 1986). Most authors state or imply that bird predation by northern pinnipeds is unusual; Ryder's (1957) report on "peaceful" associations among seabirds and several pinniped species in the Bering Sea is probably more typical. Here we give circumstantial evidence for predation on seabirds by Grey Seals around Sable Island, a large, elongate sand island some 150 km south of the nearest mainland of Nova Scotia.

The observations were made by Lucas during periodic surveys of seabirds washed up on Sable

Island. An effort was made to find every corpse along both sides of the entire length of the island, excluding the east and west tips beyond the limits of the vegetated dunes. The island has a large breeding population of Grey Seals (ca. 6 000 pups in 1984, per Zwanenburg et al. 1985), most prominent on the beaches during the breeding season in January–February, but also in numbers throughout the year. There is also a smaller population of Harbour Seals (ca. 450 pups in 1976, per Boulva and McLaren 1979), most conspicuous during summer.

During the beached-bird surveys it became evident that many of the dead birds were badly mutilated and partly or largely consumed by predators or scavengers. The incidence of these "bitten" corpses varied seasonally, but overall made up a large proportion (56–77%, Table 1). As there are no terrestrial predators on the island the agents were first thought to be Herring (*Larus argentatus*) and Great Black-backed Gulls (*L. marinus*), which are year-round residents (McLaren 1981). However, the following arguments implicate Grey Seals.

1. As already noted, Grey Seals are documented as catching and killing seabirds. Direct observations on Sable Island, however, are limited. During their winter breeding season on the island, female Grey Seals, possibly in defence of their pups, have been observed maiming or killing numbers of Great Black-backed Gulls (observations of B. Beck, in McLaren 1981). Howard Ross (personal communication) saw a Herring Gull being dragged under by a Grey Seal off the east end of the island in summer 1978.

2. Although some birds found on the beach almost without flesh had certainly been picked over by gulls, which are common beach scavengers at all times of year, other fresh corpses found in the

TABLE 1. Summary of 1986 surveys of beached birds on Sable Island, Nova Scotia, in which apparent damage by seals was observed. Those under "other" were unoiled and undamaged, or lacked damage that could be attributed to seals.

Survey dates	Numbers and condition of corpses				Species bitten ¹
	Bitten only	Oiled only	Bitten and oiled	other	
14-15 February	14	10	27	11	TBM, M, D, P
1-2 April	31	7	33	12	TBM, M, CM, D, P
9-10 May	16	9	14	14	TBM, M, D, K, F
28-29 June	45	1	3	24	S, G, M, P, R, TBM, D, L, MS, K
10-11 September	8	0	0	5	G, M
Totals	114	27	77	66	

¹In order of prevalence for each survey; symbols are: F — Northern Fulmar, *Fulmarus glacialis*; G — Greater Shearwater, *Puffinus gravis*; S — Sooty Shearwater, *Puffinus griseus*; MS — Manx Shearwater, *Puffinus puffinus*; L — Leach's Storm-Petrel, *Oceanodroma leucorhoa*; K — Black-legged Kittiwake, *Rissa tridactyla*; D — Dovekie, *Alle alle*; CM — Common Murre, *Uria aalge*; TBM — Thick-billed Murre, *Uria lomvia*; M — murre species, unidentifiable; R — Razorbill, *Alca torda*; P — Atlantic Puffin, *Fratercula arctica*.

surf or in the wash, rather than on the beach, had evidently been eaten at sea. It is unlikely that such birds could have been mutilated at sea by gulls to the extent observed. It has been suggested to us that jaegers or skuas could inflict some such damage if two or more were to struggle over a corpse. Jaegers do not occur during the winter or early spring when many corpses were found (Table 1), and skuas are very rare at all seasons (Brown 1986).

3. The damage to some birds strongly implicated something other than avian predators or scavengers. First, there were birds, particularly alcids, whose corpses were variously everted (Figure 1), suggesting that they had literally been shaken out of their skins in the manner described for Leopard Seals (Spellerberg 1975). We do not believe that skuas could evert birds in this manner at sea. Second, almost all damage where the body was more-or-less intact was to the breast and belly, suggesting that birds had been taken from below. This was particularly true of shearwaters, which were rarely everted, possibly because they are larger and less compact than alcids. Third, there were corpses with large bites out of sterna and other bone damage (Figure 2) that we believe could not be inflicted by a bird except possibly an eagle; we know of only one record of Bald Eagle, *Haliaeetus leucocephalus*, in recent years (post McLaren 1981). In summer 1986, Lucas closely observed 15 corpses of fledged gulls in areas where

other gulls must have been responsible. In most the skin of back or breast had been opened and soft parts eaten out, but none had been turned inside out or had large bones broken. Similar observations were made by McLaren on two ducks (American Black Duck, *Anas rubripes*, and Ring-necked Duck, *Aythya collaris*) consumed by Great Black-backed Gulls in Dartmouth, Nova Scotia, during January 1987: skin and most flesh on the body proper had been pulled away, but the sterna were not damaged. However, it should be noted that both eversion and damage to sterna of bird corpses has been attributed to Great Black-backed Gulls in Britain (T. J. Stowe, Royal Society for the Protection of Birds, Sandy, Bedfordshire, personal communication), although presumably such dead birds were not damaged at sea. Large sharks are possible predators on seabirds, but would probably consume entire birds. They are known to be more common around the island in summer (Brodie and Beck 1983), and might be partly responsible for the reduced incidence of beach corpses of birds at that season (see below).

4. Brian Beck (Fisheries and Oceans Canada, Bedford Institute, Dartmouth, Nova Scotia) has pointed out to us that young-of-the-year Grey Seals foraging around Sable Island from February through early summer may find it difficult to secure food, and that disabled birds may tempt them. During the February, April and May surveys (Table 1), when 94% of corpses were alcids,



FIGURE 1. The everted corpse of a Thick-billed Murre from Sable Island. Note also the extensively bitten-off right side of the sternum.



FIGURE 2. A bitten corpse of a Sooty Shearwater from Sable Island. Note damage to sternum and coracoid region.

62% of non-oiled and 74% of oiled corpses were bitten (contingency $\chi^2 = 3.50$, 1 d.f.). Although this difference is just short of significant at $P = 0.05$, it is not an unbiased measure of the possible selection of oiled versus non-oiled birds, as the latter presumably greatly predominated in the living bird population. During late June, when alcids have largely departed and there were few oiled birds (Table 1), there were 36 Sooty Shearwaters and 5 Greater Shearwaters among the 48 bitten corpses. These shearwaters are known to undergo extensive molt after arriving from the Southern Hemisphere (Palmer 1962), and might be more readily captured then. The less-common Harbour Seals produce their young in May-June. It is therefore noteworthy that casual observations by Lucas revealed very few bird corpses during summer; most of the small number found in the September survey (Table 1) appeared to have been on the beach for some time. Thus, although there is no evidence to exclude Harbour Seals altogether, Grey Seals are more likely as potential predators.

If it is true that Grey Seals eat numbers of seabirds around Sable Island, the significance of such predation can be speculated on. There appeared to be as many apparently predated birds as there were oiled birds (Table 1, totals). Of course, to the extent that predation is locally intensified, it cannot be mooted as a source of seabird mortality comparable with chronic oiling. Furthermore, as noted above, oiled alcids may be more vulnerable to capture. This means of intake of hydrocarbons by seals might be of interest. Another possible link between seabirds and seals is the avian form of influenza virus involved in mass mortalities of seals. Predation on birds could have

initiated such an interspecific transfer, thus accounting for the presence of influenza virus antibodies in apparently healthy Grey Seals on Sable Island (Geraci et al. 1984).

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Habitat Characteristics and Population Estimate of Breeding Red-throated Loons, *Gavia stellata*, on the Queen Charlotte Islands, British Columbia

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Of 184 lakes and ponds surveyed on the Queen Charlotte Islands, British Columbia, 18.5% had breeding Red-throated Loons (*Gavia stellata*). The number of loons nesting in different regions (lowland, plateau and ranges) was primarily a function of the number of lakes in the region and was unrelated to water chemistry (pH, conductivity, calcium, spectral characteristics), geography (size of pond, distance from ocean, elevation) or presence of resident fish. The population of breeding Red-throated Loons on the entire Queen Charlotte Islands was estimated by two methods at 784 or 892 pairs, with the majority nesting in the lowlands, a broad expanse of bog terrain.

Key Words: Red-throated Loon, *Gavia stellata*, Common Loon, *Gavia immer*, Queen Charlotte Islands, population estimate, breeding, geographic distribution, habitat.

Red-throated Loons, *Gavia stellata*, commonly nest on small (< 1 ha) oligotrophic lakes and occupy diverse habitats such as northern forests and tundra over a wide latitudinal and elevation range (Palmer 1962; Bundy 1976; Bergman and Derksen 1977; Cramp and Simmons 1977; Merrie 1978; Furness 1983; Reimchen and Douglas 1984a). Habitat characteristics other than pond size (Bundy 1976; Bergman and Derksen 1977; Furness 1983) are rarely quantified, and thus the variables that determine the distribution, density and population of Red-throated Loons over their circumboreal breeding range are unspecified.

As part of a study on predator/prey relationships between piscivorous birds and freshwater fish (Reimchen 1983; Reimchen and Douglas 1984b), we surveyed lakes and ponds throughout the Queen Charlotte Islands, British Columbia, for breeding Red-throated Loons. For the majority of these waters, we are able to compare habitat characteristics in lakes with or without breeding Red-throated Loons. On the basis of this sample, we provide an estimate of the breeding population of the species on the Queen Charlotte Islands.

Study Area and Methods

The Queen Charlotte Islands have three distinct physiographic regions (Sutherland Brown 1968) [see Figure 1] that coincide with general water regimes and plant communities (Calder and Taylor 1968). The Queen Charlotte lowlands contain low elevation (< 150 m), poorly drained terrain characterized by extensive areas of *Sphagnum* bog

and numerous small, shallow lakes. The Skidegate plateau consists of flat or sloping, heavily forested land mostly above 200 m. The Queen Charlotte ranges are primarily mountainous terrain with steep west-coast gradients; montane plant communities predominate on the west coast and forest communities on the east.

During the period 1975-1986, we surveyed 184 lakes and ponds (referred to hereafter as lakes) for Red-throated Loons (107 in the lowlands, 27 in the plateau and 50 in the ranges) during months (1 May to 1 September) in which Red-throated Loons are present in breeding territories. Red-throated Loons and nests were located by scanning with binoculars, and in the majority of small lakes, by walking the circumference of the lake. We defined breeding lakes by the presence of eggs, young or a territorial pair. Breeding pairs occupy nesting lakes as early as 27 March and frequent them during most of the day beginning at least in April (Reimchen and Douglas, *unpublished*). We do not consider non-breeding Red-throated Loons in this paper; these can be distinguished from territorial pairs because they occupy lakes only overnight (Reimchen and Douglas 1980). Common Loons, *Gavia immer*, also use lakes on the Queen Charlotte Islands during the summer (Reimchen and Douglas 1980) and are reported to nest in the lowlands (Godfrey 1966); we have kept records of Common Loon nests, chicks or territorial pairs.

For many lakes, water samples were taken for measurement of pH (N = 108 lakes), water colour

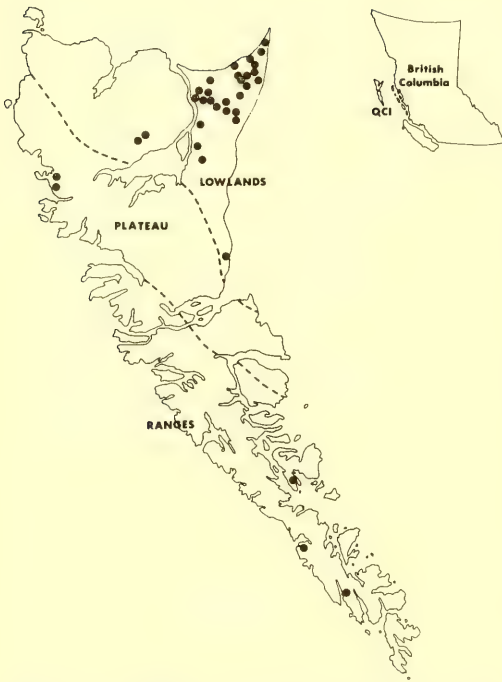


FIGURE 1. Geographic distribution of lakes with breeding Red-throated Loons, *Gavia stellata*, on the Queen Charlotte Islands (QCI). Inset — British Columbia.

(% light transmission at 400 nm, Beckman spectrophotometer; $N = 105$), conductivity and calcium concentration (argon plasma spectrometer; $N = 62$ for both). For all lakes ($N = 184$), presence or absence of fish was assessed using minnow traps and, in some lakes, seine nets. Elevation and surface area were obtained from topographical maps and aerial photographs (1 : 50 000 scale; Surveys and Mapping Branch, British Columbia Ministry of Environment); as Red-throated Loons fly to the ocean to obtain food for the young (Reimchen and Douglas 1984a), the distance from the centre of a lake to the nearest marine water was measured on maps. These eight variables, in association with region, were analyzed by stepwise discriminant analysis [BMDP7] (Jenrich and Sampson 1983) for the two groups (Red-throated Loons present or absent). Area, distance to ocean, elevation, conductivity and calcium were log-transformed. As well, discriminant analysis was performed on the data excluding variables for which the data were not complete (pH, conductivity, calcium). We also analyzed the data sets for the

lowland region separately, using the same statistical tests.

For each physiographic region, lakes with and without breeding Red-throated Loons were partitioned into lake-size classes (≤ 1 ha, 2-5 ha, 6-10 ha, 11-20 ha, 21-50 ha, 51-100 ha, 101-200 ha, > 200 ha). To estimate the breeding population, all lakes were counted and recorded in the above lake-size classes; topographical maps were used for lakes > 1 ha and aerial photographs were used for ponds < 1 ha. Aerial photographs did not allow accurate resolution below 50 m (0.25 ha). A population estimate was made for the Queen Charlotte Islands as a whole and for each lake size category within each region based on the proportion of lakes in the survey that had breeding Red-throated Loons. The population estimate is based on one pair/lake. We found only one lake that had more than one breeding pair (Reimchen and Douglas 1984a); as one nest was in the lake and the other in an inlet to the lake 700 m from the first, they were treated as occurring in separate waters for analysis.

Results

On the 184 lakes surveyed, there were 34 pairs of breeding Red-throated Loons (14 with eggs or chicks, 20 with territories), representing occupancy of 18.5% of the lakes. The majority of lakes supporting breeding pairs ($N = 29$) occurred in the Queen Charlotte lowlands.

Stepwise discriminant analysis yielded a significant difference between lakes with or without breeding Red-throated Loons ($F = 4.51$; $DF = 1, 41$; $P < 0.05$), with region as the major predictor. Occupancy of lakes was 27% in the Queen Charlotte lowlands, 7% in the Skidegate plateau and 6% in the Queen Charlotte ranges (Figure 1). When the analysis was restricted to the variables of area, elevation, distance to ocean and region, the discrimination between the groups was comparable ($F = 11.4$; $DF = 1, 170$, $P < 0.001$). Multiple regression analysis showed that the total explained variance was only 7% ($F = 2.6$, $P = 0.03$). When the analysis was restricted to lakes in the lowlands ($N = 107$), no significant differences were found between lakes with or without breeding pairs.

It was evident that Red-throated Loons used a broad range of habitats, including bog and forested terrain, and geographically and chemically diverse lakes (Table 1). Although lakes which had nests varied greatly in size (0.27-373 ha), modal lake size was less than 1 ha. Fish, including Threespine Stickleback (*Gasterosteus aculeatus*), Dolly Varden (*Salvelinus malma*), Cutthroat Trout (*Salmo clarki*), Coho Salmon (*Oncorhynchus kisutch*) and

TABLE 1. Comparison of habitat characteristics for lakes with breeding Red-throated Loons and for total lakes surveyed on the Queen Charlotte Islands. None of the differences between the two groups was significant. T400 = light transmission at 400 nm.

Habitat variable	Breeding lakes			All lakes surveys		
	average	range	N	average	range	N
pH	4.70 ($\bar{x}$)	3.95 – 6.25	20	5.34 ($\bar{x}$)	3.95 – 7.40	108
Water color (T400)	70.4% ($\bar{x}$)	37.9% – 95.0%	23	75.9% ($\bar{x}$)	37.9% – 99.8%	106
Conductivity ($\mu\text{S}/\text{cm}$) ¹	7.50 $\pm$ 25.0 (mode)	39.5 – 2200.0	14	75.0 $\pm$ 25.0 (mode)	16.5 – 4150.0	62
Calcium (ppm) ²	0.75 $\pm$ 0.25 (mode)	0.39 – 15.20	14	0.75 $\pm$ 0.25 (mode)	0.21 – 198.55	62
Distance to ocean (km)	4.1 ($\bar{x}$)	0.6 – 8.6	34	3.7 ($\bar{x}$)	0.2 – 15.8	184
Elevation (m)	52.4 ($\bar{x}$)	7.6 – 132.6	34	52.4 ($\bar{x}$)	4.6 – 228.6	184
Surface area (ha) ³	$\leq$ 1 (mode)	0.27 – 373.0	34	$\leq$ 1 (mode)	0.27 – 545.0	184

¹Partitioned into 50 $\mu\text{S}/\text{cm}$ groups for mode; ²Partitioned into 0.50 ppm groups for mode;
³Partitioned into 1 ha groups for mode.

sculpins (*Cottus* sp.) were present in 72% of the lakes. However, presence or absence of fish was not a predictor of the presence of breeding Red-throated Loons (14 lakes with fish versus 20 lakes without fish).
The Queen Charlotte Islands contain over 3000 lakes and ponds, 82.5% of which are located in the Queen Charlotte lowlands (Table 2). In the lowlands and the plateau, the majority of these are less than 1 ha in size, while the Queen Charlotte

ranges contain fewer and larger lakes. It appeared that none of the habitat characteristics that were measured, other than region, had an effect on the distribution of pairs. Thus, in calculating the total breeding population, lakes within regions, but not between regions, were considered to have equal potential for nests. Based on the proportion of lakes that had breeding pairs, a population estimate of 744 breeding pairs was obtained for the lowlands, 24 for the plateau and 16 for the ranges,

TABLE 2. Actual and estimated numbers of breeding pairs of Red-throated Loons on the Queen Charlotte Islands in relation to lake size and region. Population estimates are calculated for (a) lake-size classes within a region, (b) cumulative lake-size classes, and (c) total lake number in each region, independent of lake size.

	Size of lake (ha)								Population estimate (pairs)	
	$\leq$ 1	2-5	6-10	11-20	21-50	51-100	101-200	$>$ 200	Total	lake size ^b region ^c
Queen Charlotte Lowlands										
number of lakes in region	2534	151	21	18	11	6	1	3	2745	
number of lakes surveyed	27	45	11	10	7	6	0	1	107	
number of breeding pairs	7	12	2	1	3	3	0	1	29	
population estimate ^a (pairs)	657	40	4	2	5	3	0	3		714 744
Skidegate Plateau										
number of lakes in region	243	42	9	14	7	3	1	3	322	
number of lakes surveyed	3	8	4	7	2	2	0	1	27	
number of breeding pairs	2	0	0	0	0	0	0	0	2	
population estimate ^a (pairs)	162	0	0	0	0	0	0	0		162 24
Queen Charlotte Ranges										
number of lakes in region	78	100	23	27	20	7	5	1	261	
number of lakes surveyed	5	13	4	11	11	3	2	1	50	
number of breeding pairs	0	1	1	0	1	0	0	0	3	
population estimate ^a (pairs)	0	8	6	0	2	0	0	0		16 16
population estimate ^a (pairs)	819	48	10	2	7	3	0	3		892 784

yielding a total of 784 breeding pairs for the entire Queen Charlotte Islands. This represented a density of 0.23 pairs/km² in the lowlands, 0.007 pairs/km² in the plateau and 0.005 pairs/km² in the ranges (overall density, 0.079 pairs/km²). These densities primarily reflect densities of ponds in each region. A population estimate was also calculated for each lake-size class in each region (Table 2); this yielded a cumulative total of 892 breeding pairs for the Queen Charlotte Islands as a whole.

These estimates have several possible sources of error. Population estimates were heavily weighted by the preponderance of small ponds (< 1 ha) in the lowlands. Resolution in aerial photographs did not allow reliable identification of ponds less than 0.25 ha and, therefore, the number of these ponds may have been greatly underestimated. Although Red-throated Loons have been recorded nesting on ponds 15 m² (0.0015 ha) (Furness 1983), we have not observed them on ponds less than 0.27 ha despite extensive ground surveys. However, it remains possible, given the immense numbers of small ponds, that some are used by breeding Red-throated Loons; if so, our population estimates will be low.

Our estimates do not take into account the patchiness of pond distribution. Where ponds occur very densely, numbers of pairs may be limited by spacing between nests; in such areas, there may be fewer pairs than estimated by average occupancy rate. To assess the importance of this effect, we analyzed separately the area where ponds occurred at exceptionally high density. This area, in the central lowlands, is 30.75 km² and has 373 lakes. At the calculated occupancy rate for the lowlands, there should be 101 pairs or 3.3 pairs/km². If we assume a minimum distance between nests of 700 m (see Study Area and Methods), the area would support only 62 pairs; this would reduce the total population estimate by 39 pairs (5%).

Common Loons with chicks were observed in two lakes, both in the lowlands; territorial pairs were found in two lakes, one in the plateau and one in the ranges. Lake size ranged from 13-53 ha; breeding Red-throated Loons were not present on these lakes.

Discussion

On the Queen Charlotte Islands, lakes which had nesting Red-throated Loons showed variation in water colour, pH, conductivity, calcium, lake size, elevation, distance to the ocean and presence of resident fish. Breeding pairs appeared to occupy

lakes according to their availability rather than to any of these measured parameters.

In other geographic areas, competition with Pacific Loons (*Gavia pacifica*) for breeding territories is considered to restrict the distribution of breeding Red-throated Loons. Where the two species are sympatric, they partition the habitat, with Red-throated Loons occupying smaller lakes (Davis 1972; Bergman and Derksen 1977; Merrie 1978). Although occasional summer migrants have been observed on the Queen Charlotte Islands (Reimchen and Douglas 1984b), breeding Pacific Loons are absent.

Breeding Common Loons are infrequent on the Queen Charlotte Islands (4 territories/184 lakes) and are thus unlikely to have a major influence on the distribution of breeding Red-throated Loons. However, non-breeding Common Loons use large lakes on the islands for foraging (Reimchen and Douglas 1980), and where they overlap with breeding Red-throated Loons, aggressive encounters occur (Reimchen and Douglas 1985). Common Loons are limited in the size of fishing lakes they use on the Queen Charlotte Islands by a minimum distance (approximately 300 m) for taking-off and gaining altitude sufficient for leaving the lake. There is, therefore, a potential for interactions between the two loon species on lakes down to about 2 ha (a size on which we have observed Common Loons). If Common Loons are restricting the breeding distribution of Red-throated Loons, Red-throated Loons should be less common on those lakes greater than 2 ha that have fish than on those where fish are absent. Yet our data showed that there was no significant difference in occupancy (13.2% occupancy of lakes ≥ 2 ha with no fish ($N = 53$) and 18.8% with fish ($N = 96$); G test, $G = 0.42$, $DF = 1$, NS), suggesting that non-breeding Common Loons were not restricting the distribution of Red-throated Loons.

Red-throated Loons use smaller nesting lakes than any of the other loon species (Palmer 1962; Cramp and Simmons 1977; Bergman and Derksen 1977; Merrie 1978). Norberg and Norberg (1971) reported a take-off distance of 15-40 m for Red-throated Loons; this may be a lower limit for size of most breeding ponds, although, on Foula, pairs nested on ponds less than 15 m long and successfully raised young (Furness 1983). In Alaska, nesting ponds of Red-throated Loons ranged from 0.1-0.8 ha ($\bar{x} = 0.4$ ha); their distribution is probably influenced by nesting Pacific Loons who occupied larger ponds ($\bar{x} = 3.0$ ha, range = 0.7 - 12.1 ha) (Bergman and Derksen 1977). Bundy (1976) suggested that breeding Red-

throated Loons on Unst, Shetland Islands, had a preference for lakes less than 1 ha. We have re-examined his data and found that, rather than exhibiting a preference for small tarns, Red-throated Loons were nesting according to the availability of size classes of lakes: of 96 lakes < 1 ha, 19.8% were occupied, of 14 lakes 1 – 5 ha, 21% were occupied and of 10 lakes > 5 ha, 20% were occupied. As in our study, the preponderance of pairs nesting on small lakes reflected the abundance of lakes of that size; it did not imply a habitat preference.

Red-throated Loons are exceptional among the Gaviidae in that they do not feed their young with food from the nesting lake, but fly to marine water or to larger lakes to obtain fish (Norberg and Norberg 1971; Bundy 1976; Bergman and Derksen 1977; Merrie 1978; Furness 1983; Reimchen and Douglas 1984a). Thus, it is not unexpected that the use of lakes for breeding is independent of the presence of fish or of limnological characteristics which may relate to productivity (conductivity, calcium and pH).

The maximum distance from Red-throated Loon breeding lakes to the nearest marine water on the Queen Charlotte Islands was 8.6 km. For 85 pairs of breeding Red-throated Loons in Scotland, the majority of feeding flights were within 8 km of the nest site (Merrie 1978). As increased distance to the foraging grounds will limit the number of return flights per day and thus the number of fish fed to the young, as well as expose the young to increased periods without parental guarding (Reimchen and Douglas 1985), survivorship of the young could be reduced on lakes at increasing distances from the ocean. We found no reduction in occupancy over the short distances to feeding grounds on the Queen Charlotte Islands; however, fledging success at differing distances to the ocean is unknown. On the Shetland Islands, Gomersall (1986) compared pairs that nested less than 1 km from the ocean to pairs nesting more than 1 km and found no significant difference in hatching or fledging success.

Physiographic region was the only significant predictor of the presence or absence of breeding pairs of Red-throated Loons on the Queen Charlotte Islands, with lakes in the lowlands having a higher occupancy than those in the plateau or ranges. Several characteristics that are correlated with region — plant communities, lake density and proximity to fishing areas — may explain this distribution. The lowlands are dominated by extensive areas of *Sphagnum* bog; lakes and bog pools often have convoluted

Sphagnum-covered shorelines and low islets which are typical nest substrates for Red-throated Loons (Cramp and Simmons 1977; Dement'ev and Gladkov 1969; Davis 1972). Ponds in this region usually have short vegetation on their shores which may facilitate landing and take-off; in small ponds that have forested shores, Red-throated Loons must do tight aerial turns to gain altitude during take-off (Norberg and Norberg 1971; personal observation). Red-throated Loons in Alaska nested on shallow ponds with emergent shoreline vegetation (Derksen et al. 1981) and, in comparison to Pacific Loons, occupied those with greater vegetative cover (Bergman and Derksen 1977). Aquatic vegetation was not quantified in our survey and as such, presence or absence of breeding Red-throated Loons according to percentage coverage cannot be assessed. In general, however, ponds and lakes in the lowlands are dystrophic, with low diversity and abundance of plants, while those in the plateau and ranges are oligotrophic, with comparatively higher diversity but similar low abundance (Calder and Taylor 1968).

The lowlands have a higher density of lakes than the other two regions. In the Northwest Territories, the availability of alternate lakes was found to be important for predator escape (Davis 1972); as well, chicks incubated on small ponds may be able to move to larger lakes for fledging (Bergman and Derksen 1977; Furness 1983). Thus, successful fledging of young may depend on a certain density of ponds and a territory larger than the nesting pond.

Merrie (1978) postulated that the distribution of breeding Red-throated Loons on lakes in Scotland was based on the availability of shallow fishing areas. The higher occupancy of lakes in the lowlands may similarly relate to the proximity of broad littoral marine feeding areas to the north and east (see Figure 1). Conversely, for most of the plateau and ranges, the nearest marine water lies on the Islands' west coast, where the continental shelf is very narrow and even nearshore water is deep.

On the Queen Charlotte Islands, occupancy of lakes (27% in the lowlands, 18.5% overall) appears low, yet comparable numbers are found on the Shetland Islands, Scotland (Unst: 20% to 33%, $N = 120$, Bundy 1976; Foula: 82%, $N = 17$, Furness 1983). Although the habitat characteristics we investigated did not appear to affect the suitability of lakes for breeding, there may be other constraints limiting occupancy. Competition does not seem important, since apart from occasional

Common Loons, Red-throated Loons are the only large divers observed nesting on these lakes. If absolute numbers of Red-throated Loons are limited in their winter distribution, low occupancy may represent deficiencies in numbers of breeding birds. This appears unlikely, as there is a relatively large number of non-breeding adult Red-throated Loons utilizing marine waters in the day and overnighing on large lakes throughout the breeding season (Reimchen and Douglas 1980).

In contrast, low occupancy rate may be a result of spacing of nesting territories, which is maintained by territorial displays and vocalizations. We suspect this is also unlikely, as maximum density in the lowlands (0.23 pairs/km) is substantially lower than that observed in Scotland (0.84 pairs/km²; Merrie 1978), Alaska (0.40 pairs/km²; Bergman and Derksen 1977) and the Northwest Territories (1.7 pairs/km²; L. Dickson, Canadian Wildlife Service, personal communication).

Occupancy may be limited by foraging success in the marine habitat. The major diet of the young during the 50-day pre fledging period, during which adult birds bring prey of particular taxa and size depending on the age of the chick, is obtained from marine foraging areas (Reimchen and Douglas 1984a). It is possible that the ability to maintain suitable marine feeding territories can influence the establishment and maintenance of their breeding territories and, therefore, limit the number of occupied lakes.

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New Canadian Records of Leeches (Annelida : Hirudinea) Parasitic on Fish

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Madill, Jacqueline. 1988. New Canadian records of leeches (Annelida : Hirudinea) parasitic on fish. *Canadian Field-Naturalist* 102(4): 685-688.

Thirteen new host and 26 new locality records of leeches (Hirudinea) known to be parasitic on fish are reported from Canadian waters. *Beringbdella rectangulata*, *Malmiana virida*, *Oceanobdella pallida*, and *Ostreobdella papillata* are recorded in Canada for the first time.

Key Words: Leech, Hirudinea, fish, parasitic, Canada, distribution.

A recent inventory of the Annelida collection, National Museum of Natural Sciences, Ottawa, uncovered new host and distribution records for leeches known to be parasitic on fish. Hosts (13) and localities (26) reported here for the first time are designated New hosts and New localities. Each record lists catalogue number (NMCA), date collected, locality, host, and attachment site. When more than one sample of specimens in the Annelida collection represents a new host or locality, the specimens collected first are followed by the catalogue numbers of the additional material.

All Hirudinea identifications have been verified by the author unless otherwise indicated.

Family Piscicolidae (fish leeches)

Beringbdella rectangulata (Levinsen 1882).

First Canadian record.

NMCA1983-0702. February 1976. New locality: Hecate Strait, British Columbia, Pacific Ocean, 53°N, 131°W. Host: *Gadus macrocephalus* Tilesius 1810, Pacific Cod. Site: inner buccal wall. (Additional material from this locality: NMCA-1983-0699, NMCA1984-0176, NMCA1984-0177, NMCA1984-0178.)

B. rectangulata has been recorded from the Bering Sea and the Gulf of Alaska and is specific to cod (Moore and Meyer 1951); six of 27 cod in Hecate Strait were infected.

Calliobdella vivida (Verrill 1872).

NMCA1982-0618. 12 July 1954. New locality: St. George River estuary, Newfoundland, Atlantic Ocean, 49°25'N, 58°32'W. Collected free-living at the low water mark on a pebble beach. *C. vivida* has been recorded from the east coast of the United States and as far north as the Bay of Fundy, New Brunswick (Appy and Dadswell 1981).

Calliobdella sp.

NMCA1984-0478. 1 March 1984. New locality: Alice Arm, Portland Inlet, British Columbia, Pacific Ocean, 55°27'N, 129°29'W. New host. *Limanda aspera* (Pallas 1811), Yellowfin Sole. Site: fins, body. (Additional material from this locality: NMCA1984-0844, NMCA1984-0845, NMCA1984-0846.)

The pigmentation of these specimens differs from the description of *Calliobdella knightjonesi* recorded in Oregon (Bureson 1984) from *Parophrys vetulus*, and indicates that these specimens from Alice Arm are not the same species.

Johannsonia arctica (Johansson 1898).

NMCA1982-0622 and NMCA1982-0624. 27 July 1952. New locality: Prince Patrick Island, Queen Elizabeth Islands, Northwest Territories, Arctic Ocean, 76°14'N, 119°20'W. (Additional material from this locality: NMCA1982-0623.) Collected free-living with a bottom dredge.

J. arctica has been recorded from the south coast of the Alaskan Peninsula (Moore and Meyer 1951), Newfoundland, the Kara Sea and Greenland (Meyer and Khan 1979).

Malmiana virida Bureson 1977.

First Canadian record.

NMCA1982-0678. 5 July 1970. New locality: Long Beach, Vancouver Island, British Columbia, Pacific Ocean, 49°05'N, 125°51'W. Collected free-living at the low water mark on bedrock.

This specimen is fragmented but the horizontal pigmentation is visible. *M. virida* has been recorded from Oregon (Bureson 1977a).

Malmiana spp.

NMCA1984-0840. 16 July 1984. Locality: Vancouver Public Aquarium in Stanley Park, Vancouver, British Columbia, 49°N, 123°W. New host: *Anarrhichthys ocellatus* Ayres 1855, Wolf Eel. Site: pectoral fin.

NMCA1984-0175. 11 June 1983. New locality: Bonilla fishing grounds, Hecate Strait, British Columbia, Pacific Ocean, 53°31'N, 130°52'W. New host: *Lepidopsetta bilineata* (Ayres 1855), Rock Sole. Site: gill.

NMCA1986-0105. 8 November 1985. New locality: Clayoquot Canyon fishing grounds, west coast of Vancouver Island, British Columbia, Pacific Ocean, 49°N, 126°45'W. New host: *Merluccius productus* (Ayres 1855), Pacific Hake. Site: posterior body.

NMCA1986-0099. 30 October 1985. New locality: Grouse Island Grounds, Queen Charlotte Sound, British Columbia, Pacific Ocean, 52°19'N, 130°21'W. New host: *Sebastes alutus* (Gilbert 1890), Pacific Ocean Perch. Site: body. (Additional material from this locality: NMCA1986-0098.)

NMCA1986-0101 to NMCA1986-0104. 5 November 1985. New locality: Langara Spit grounds, Dixon Entrance, British Columbia, Pacific Ocean, 54°12'N, 133°45'W. New host: *Sebastolobus alascanus* Bean 1890, Shortspine Thornyhead. Site: eye.

NMCA1982-0680. 15 August 1964. New locality: Winton Bay, Baffin Island, Northwest Territories, Arctic Ocean, 63°24'N, 64°40'W. Host: *Myoxocephalus scorpius* (Linnaeus 1758), Shorthorn Sculpin. Site: pectoral fin. (Additional material from Baffin Island: NMCA1982-0683, NMCA1982-0685.)

The genus *Malmiana* has been reported from Canadian oceans in the following areas: *M. diminuta* from *Sebastes* sp., Rockfish; *Scorpaenichthys marmoratus*, Cabezon; and *Ophiodon elongatus*, Lingcod in the Vancouver Aquarium at Stanley Park (Burreson 1977a); *M. scorpii* from sculpins in Bernard Harbour, Northwest Territories (Moore 1921); *M. scorpii* and *M. brunnea* from sculpins in New Brunswick (Appy and Dadswell 1981) and Newfoundland (Khan and Meyer 1976).

Myzobdella lugubris Leidy 1851.

NMCA1982-0699. 2 May 1961. New locality: Southwest of Sable Island, Nova Scotia, Atlantic Ocean, 43°57'N, 61°44'W. Host: *Anarhichas lupus* Linnaeus 1758, Atlantic Wolffish.

M. lugubris has been reported only from fresh and estuarine conditions in the east coast of the United States, and in Sackville marsh, New Brunswick (Appy and Dadswell 1981). Although the external morphology and internal anatomy of these specimens from Nova Scotia strongly resembles other specimens of *M. lugubris* from eastern North America, this purely marine record taken at a depth of 85 metres is unusual.

Notostomum cyclostomum (Johansson 1898).

NMCA1978-0341. 20 August 1955. New locality: Slidre Fiord, Ellesmere Island, Northwest Territories, Arctic Ocean, 79°59'N, 85°57'W.

NMCA1984-0744. 1 September 1965. New locality: Starvation Cove, Victoria Island, Northwest Territories, Arctic Ocean, 69°10'N, 106°28'W. (Additional material from this locality: NMCA1984-0743.)

NMCA1984-0745. 20 August 1970. New locality: Frobisher Bay, Baffin Island, Northwest Territories, Arctic Ocean, 62°44'N, 65°35'W. (Additional material from this locality: NMCA1982-0614.) Collected free-living by hand, trawl and dredge.

N. cyclostomum has been recorded from the Bering Sea on *Raja* sp., skate (Moore and Meyer 1951) and from British Columbia on *Hippoglossus stenolepis*, Halibut (Sloan et al. 1984). Believed to be a "free-ranging, predacious hunter" (Moore and Meyer 1951), *N. cyclostomum* has frequently been recorded from *Paralithodes camtschatica*, Red King Crab, *Lithodes aequispina*, Golden King Crab, and *Chionoecetes bairdi*, Tanner Crab, on which it deposits its cocoons, or free-living (Sloan et al. 1984).

Oceanobdella pallida Burreson 1977.

First Canadian record.

NMCA1984-0173. 9 June 1983. New locality: Hecate Strait, British Columbia, Pacific Ocean, 53°N, 130°W. Host: *Parophrys vetulus* Girard 1854, English Sole. Site: body, gills. (Additional material from this locality: NMCA1984-0171 to NMCA1984-0174, NMCA1984-0179, NMCA1984-0461 to NMCA1984-0470.)

O. pallida has been recorded from *P. vetulus* in Oregon (Burreson 1977c). The author observed movement of these leeches from the body into the opercular area upon removal of the host from water.

Oceanobdella sexoculata (Malm 1863).

NMCA1984-0793. 3 June 1983. New locality: St. Lawrence River estuary, Quebec, Atlantic Ocean, 47°26'N, 70°28'W. Host: *Macrozoarces americanus* (Bloch and Schneider 1801), Ocean Pout. Site: inner buccal wall.

O. sexoculata has been reported from *M. americanus* in Canadian oceans in Newfoundland (Khan and Meyer 1976) and New Brunswick (Appy and Dadswell 1981).

Ostreobdella papillata Burreson 1977.

First Canadian record.

NMCA1984-0837. 16 July 1984. New locality: Vancouver Public Aquarium at Stanley Park,

Vancouver, British Columbia, 49°N, 123°W. New host: *Sebastes nigrocinctus* Ayres 1859, Tiger Rockfish. Site: head and body. (Additional material from this locality: NMCA1984-0841, NMCA1984-0582.)

O. papillata has been recorded from *Sebastes melanops*, Black Rockfish, and *Octopus dofleini*, Pacific Giant Octopus, in Oregon (Bureson 1977b).

Piscicola geometra (Linnaeus 1758).

NMCA1985-0379. 30 October 1985. Locality: Heart Lake, Quebec, 45°46'N, 75°14'W. New host: *Coregonus artedii* Lesueur 1818, Cisco.

NMCA1977-0407. 24 May 1959. Locality: Blue Sea Lake, Quebec, 46°11'N, 76°3'W. New host: *Salvelinus namaycush* (Walbaum 1792), Lake Trout. Identified by J. E. Moore in 1964.

NMCA1984-0218. 30 May 1978. Locality: Bigstone Lake, Saskatchewan, 55°7'N, 105°21'W. New host: *Perca flavescens* (Mitchill 1814), Yellow Perch. (Additional material from this locality: NMCA1984-0206.)

NMCA1984-0226. 20 June 1978. New locality: Cree Lake, Saskatchewan, 57°20'N, 106°40'W. New host: *Coregonus clupeaformis* (Mitchill 1818), Lake Whitefish. (Additional material from this locality: NMCA1984-0227.)

Cree Lake is the northernmost record for Saskatchewan. Cree Lake, which flows into the Arctic drainage, is isolated from the closest record, Froebisher Lake (Oliver 1958), which flows into the Churchill River. *P. geometra* is not host selective but was recorded on Coregoninae and Salmoninae in Europe and North America (Meyer 1940), and on *Perca fluviatilis*, Perch (Elliott and Mann 1979) in Europe.

Piscicola milneri (Verrill 1874).

NMCA1984-0754. 4 April 1984. Locality: Willow Lake, Pukaskwa National Park, Ontario, 48°28'N, 86°1'W. New host: *Salvelinus fontinalis* (Mitchill 1815), Brook Trout. Site: posterior body.

P. milneri has been recorded from other salmonids (Meyer and Moore 1954).

Piscicola punctata (Verrill 1871).

NMCA1987-0397. 15 January 1985. New locality: Tay River, Alberta, 52°3'N, 115°5'W. Host: *Salvelinus fontinalis* (Mitchill 1815), Brook Trout.

The Tay River is the northernmost record for Alberta. The closest record is Chestermere Lake, also in the South Saskatchewan River drainage (Davies 1973). The only other Canadian record from *S. fontinalis* is from Ontario streams (Ricker 1932).

Platybdella anarrhichae (Diesing 1859).

NMCA1982-0708. 2 May 1961. New locality: Southwest of Sable Island, Nova Scotia, Atlantic Ocean, 43°57'N, 61°44'W. Host: *Anarrhichas lupus* Linnaeus 1758, Atlantic Wolffish.

The closest records are from New Brunswick (Appy and Dadswell 1981) and Newfoundland (Meyer and Khan 1979) on *A. lupus*.

Family Hirudinidae (true bloodsuckers)

Percymoorensis marmoratis (Say 1824).

NMCA1985-0264. Summer 1907. Locality: Qu'Appelle Valley, Saskatchewan, 50°46'N, 103°38'W. New host: *Stizostedion vitreum* (Mitchill 1818), Walleye.

P. marmoratis is a macrophagous predator (Sawyer 1986), an opportunistic feeder and not a true parasite.

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Predation on Narwhals, *Monodon monoceros*, by Killer Whales, *Orcinus orca*, in the Eastern Canadian Arctic

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Campbell, R. R., D. B. Yurick, and N. B. Snow. 1988. Predation on Narwhals, *Monodon monoceros*, by Killer Whales, *Orcinus orca*, in the eastern Canadian Arctic. *Canadian Field-Naturalist* 102(4): 689-696.

Killer Whales (*Orcinus orca*) are considered uncommon in Canadian Arctic waters and have not been thought to be frequent predators of Narwhals (*Monodon monoceros*). Observations of Killer Whale attacks in the Eclipse Sound area off the north coast of Baffin Island, Northwest Territories indicate this may not be the case. There is evidence to confirm that Killer Whales are predators of Narwhals and that the Narwhals have evolved specific defensive strategies in response to Killer Whale predation. Inuit hunters recognize and capitalize on the behavioural responses reflecting these defensive strategies. Therefore the effects of Killer Whale predation on mortality in Narwhals have both direct and indirect components.

On considèrerait la présence des Epaulards (*Orcinus orca*) dans les eaux arctiques Canadiennes très infrequent et qu'elles n'étaient pas un prédateur significatif des Narvals (*Monodon monoceros*). Les observations d'attaques d'Epaulards dans les régions du Détroit d'Eclipse à la côte du nord de l'Isle de Baffin, les Territoires du Nord-Ouest indiquent que ce n'est pas le cas. Il y a évidence de corroborer que les Epaulards sont prédateurs des Narvals et que les Narvals ont développés des stratégies défensive spécifique en réponse à la prédation des Epaulards. Les chasseurs Inuit reconnaissent et profitent de ces réactions de comportement. Donc, les effets des Epaulards sur la mortalité des Narvals ont des constituants tant immédiate que oblique.

Key Words: Killer Whale, *Orcinus orca*, Narwhal, *Monodon monoceros*, predation, Lancaster Sound.

Killer Whales (*Orcinus orca*) are found in all the world's oceans but are perhaps most abundant in cold temperate and polar waters (Mitchell 1975; Davis et al. 1980; Watson 1981; Perrin 1982; Lopez and Lopez 1985). In the eastern Canadian Arctic, they occur in eastern Lancaster Sound, Davis Strait and eastern Hudson Strait (Figure 1), particularly in late summer after the disappearance of the pack ice (Davis et al. 1980).

Although the species is widely distributed it has not been the subject of intensive study until recent years. Martinez and Klinghammer (1970) reviewed the early literature and more recent reviews have been carried out through the International Whaling Commission (Mitchell 1975; Perrin 1982). Bigg (Bigg et al. 1976; Bigg 1982) and Balcomb (Balcomb et al. 1980, 1982) have assessed the stocks of the Pacific coast of North America, but very little information exists concerning these stocks in the waters of the western North Atlantic and the eastern Canadian Arctic. The behaviour and strategies used by the species in attacking mysticetes and other marine mammals have received limited attention (Martinez and Klinghammer 1970; Mitchell and Reeves 1982). Recently Lopez and Lopez (1985) documented the

behaviour of Killer Whales while hunting nearshore in southern Argentina. Known prey include species of fish, squid, seals, birds and other whales (Perrin 1982: Appendix 4). Killer Whales have also been reported to prey on almost all species of cetaceans including Beluga (*Delphinapterus leucas*) (Kleinenberg et al. 1964), Humpback (*Megaptera novaeangliae*) (Whitehead and Glass 1985) and Gray Whale (*Eschrichtius robustus*) (Ljungblad and Moore 1983), and they may be one of the factors limiting the recovery of the Bowhead Whale (*Balaena mysticetus*) in the eastern Canadian Arctic (Mitchell and Reeves 1982; Finley et al. 1986).

Killer whales are also known to attack Narwhals although, until the eyewitness account of Steltner et al. (1984), evidence was obtained from Inuit observers (Degerbøl and Freuchen 1985; Freuchen and Salomonsen 1958). There is very little information about natural mortality of Narwhals and Killer Whales have been presumed not to be significant predators (Davis et al. 1980). However, the evidence presented here suggests that Killer Whales, although uncommon in the range of Narwhals, may be an important predator of this species.



FIGURE 1. Lancaster Sound and adjacent waters. The area of observation is enlarged in Figure 2.

Time and Place of Observations

During August 1985, while working in the vicinity of Eclipse Sound, (Figure 2) we were able to observe a number of events related to Killer Whale predation on Narwhals. The Baffin Island Oil Spill (BIOS) research camp at Cape Hatt overlooks a natural lagoon (local name "Z" Lagoon) which is the site of research activities related to environmental effects of hydrocarbon spills and clean-up technology. The site was occupied throughout the summer research period each year from 1980 to 1983 and again in 1985. The lagoon is clearly visible from the working and living quarters so that any unusual activity in the area could be noted by camp workers. On 20 August 1985, during an aerial reconnaissance of the Eclipse Sound area as part of an evaluation of a proposed national marine park, we were able to observe Narwhals and Killer Whales in Milne Inlet and the apparent results of attacks by the latter on the former.

Observations

Killer Whales and Narwhals had been noted in the Eclipse Sound area throughout early August by Inuit hunters and were observed in Tremblay Sound throughout early to mid-August by a Department of Fisheries and Oceans (DFO) research team working in the area. On 12 August 1985, about 100 Narwhals entered "Z" Lagoon near the Cape Hatt BIOS camp and remained there for one day before departing. A similar event had been observed by researchers at the facility once before in 1982, when 150 to 200 Narwhals entered "Z" Lagoon and remained there for about three days.

On 17 August 1985, a wounded female Narwhal was found on the southeast shore of "Z" lagoon. The animal was presumed by NBS to have beached itself on the high tide earlier that day or the night before. It was still alive when found but was later killed and the muktuk and meat removed by local hunters. The whale was quite dry when inspected

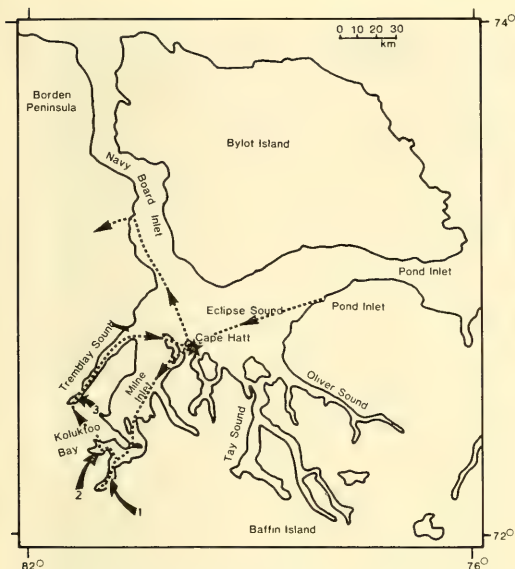


FIGURE 2. Pond Inlet — Eclipse Sound area indicating area of observations.

-----> General outward flight path.

★ "Z" Lagoon, location of the BIOS Camp and the beached Narwhal.

🐋 Killer Whale sighting.

➔ Narwhal sightings: (1) Assumption Harbour; (2) Koluktoo Bay; (3) Tremblay Sound.

by one of us and the skin was rapidly darkening in the sun. The last metre or so on the right side, including the caudal peduncle and flukes, was marked with numerous, almost parallel lacerations (Figure 3). These were several centimeters long and about 1 cm wide. Additionally there was a semi-circular marking about 30 cm across, immediately ahead of the body lacerations, composed of pencil-diameter punctures separated by 2–3 cm.

During the afternoon of 20 August 1985, a small pod of nine Killer Whales [one mature bull with cows and juveniles (Figure 4)] was observed, at the entrance to Koluktoo Bay in Milne Inlet (Figure 2). The whales were moving in an easterly direction, nine abreast. The movement was leisurely and the animals gave no indication of reaction to the helicopter even when the aircraft was less than 50 m overhead. The whales made frequent shallow dives of short duration (<1 min), surfacing, blowing and diving almost synchronously and giving the impression that they were patrolling the mouth of Koluktoo Bay.

Approximately 15 to 20 minutes later, a group of 300 or more Narwhals was observed in the southern part of Milne Inlet, in the vicinity of



FIGURE 3. A photograph of the posterior third of the female Narwhal beached at Cape Hatt, 16–17 August 1985, indicating the the semi-circular mark which may represent an unsuccessful bite of a Killer Whale. The parallel lacerations may be cracks resulting from long exposure of the skin to air (the carcass may have been floating with the tail stock exposed) and also from 'nibbling' by fulmars, which relish 'muktuk'.

Assumption Harbour, well south of Koluktoo Bay. A smaller number of Narwhals (100 to 150) was subsequently sighted close to the southern shore of Koluktoo Bay and, about 30 minutes later, another group of 125 to 150 Narwhal was sighted in the upper reaches of Tremblay Sound (Figure 2). In all three instances the whales were close to shore in depths of less than 100 m. They were grouped in small pods of four to fourteen animals and appeared to be lying at the surface with very little movement. The approach of the helicopter resulted in the animals making shallow dives and moving away from the flight path at, or near, the surface. On several occasions diving of a pod was initiated by one or more individuals lifting their tusks from the water and bringing them down on the backs of other Narwhals (Figure 5).

The Assumption Harbour group consisted mostly of tusked males with a few cows and calves. Although the pods in Tremblay Sound and south Koluktoo Bay had a higher proportion of cows and calves than the other group, males were predominant in these pods as well. Several animals in Milne Inlet appeared to have recently inflicted wounds, as evidenced by large white patches of raw blubber, most often near the head (Figure 6) and flukes. One animal, possibly a juvenile, displayed a large open wound on the side of the head and the blubber was stained pink with blood. It appeared that the animal was being borne up in the water by an attendant group of large males.

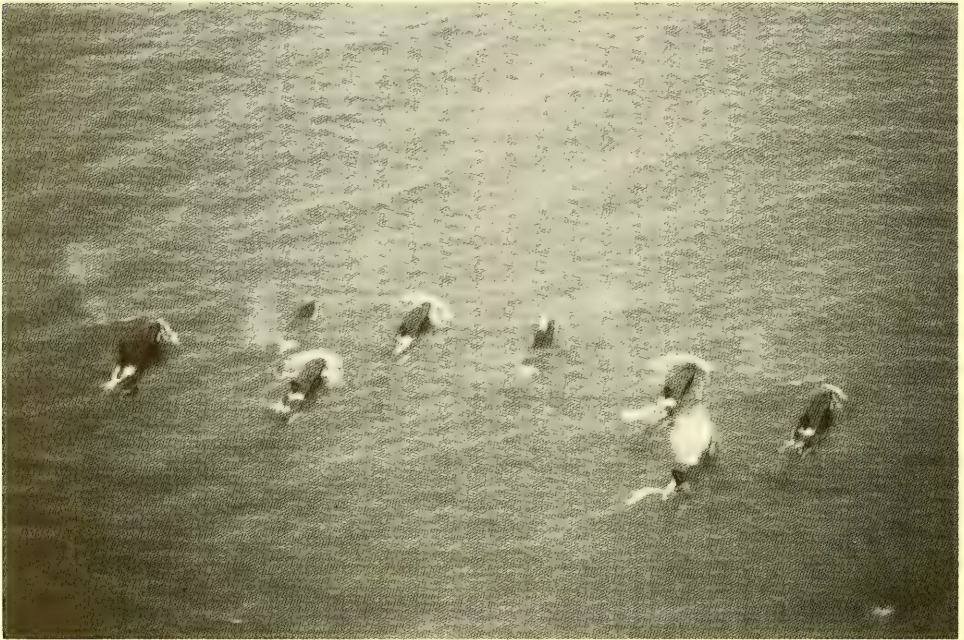


FIGURE 4. Photograph of the Killer Whale pod observed near Cape Hatt 20 August 1985. Note the large male on the left.

Discussion

Ford et al. (1986), while studying underwater vocalizations of Narwhals in Koluktoo Bay, were more directly able to observe the effects of Killer Whales on Narwhal behaviour and vocalizations. They described a pod of 12 Killer Whales (three mature bulls, two to three juveniles and six to seven cows and immature animals), entering Koluktoo Bay on 15 August when 200 Narwhals were estimated to be in the Bay. When the Killer Whales appeared the Narwhals moved to shallow water close to shore and ceased vocalizing at the time of the first Killer Whale vocalization. Ford et al. (1986) also reported that Ringed Seals (*Phoca hispida*) in the area also moved to within 25 m of the shore and congregated there for some time after the departure of the Killer Whales. The scene was repeated on the afternoon of 16 August when the Killer Whales were observed feeding on a Narwhal. On this occasion the Narwhals left the bay some hours after the departure of the Killer Whales but returned the following day. The same group of Killer Whales was observed in the bay on both 19 and 20 August, killing a Narwhal on the 19th. Their appearance on the latter occasions did not seem to inhibit Narwhal vocalizations.

Although neither the authors nor Ford et al. (1986), directly observed an actual attack of Killer Whales on Narwhals or the Killer Whale behaviour described by Steltner et al. (1984), the observed behavioural responses of Narwhals (i.e. sheltering in shallow water, limited movement and vocalization) to Killer Whales was consistent with Inuit information and other documented observations (Martinez and Klinghammer 1970; Finley et al. 1984). The Inuit not only recognize but exploit the reaction of Narwhals and seals to Killer Whales to harvest them when they are in the shallows. In Inuktitut the behavioural response is summed in one word, "ardlingayuk" — literally translated as "fear of Killer Whales" (Finley et al. 1984). Inuit hunters know that whales and seals seek shelter in the loose pack ice, under the ice edge, or in shallow water in the absence of ice and they have also observed that the whales cease vocalizing when Killer Whales are in the area. This behaviour was noted by Finley et al. (1984) in reaction to an approaching ship.

Narwhals, unlike Belugas, are not usually found in shallow waters and in the summer months they seem to prefer the deeper waters of steep, sheltered fiords and bays for calving and feeding (Mansfield



FIGURE 5. Photograph of a pod of 11 adult male Narwhals displaying the raising of the tusk by one individual over the back of another prior to diving on approach of the helicopter.

1983; Larsen 1984). The movement of Narwhals into the shallow waters of Milne Inlet and Tremblay Sound is thought to be unusual although the animals have been frequently observed by DFO observers and others (Ford et al. 1986) during August in the deeper waters of both locations. The use of shallow waters and nearshore areas has been previously postulated as a useful strategy for some odontocetes in the avoidance of Killer Whales (Wells et al. 1980; Würsig and Würsig 1980). Biologically noisy shorelines and limited depth may confuse the echolocation and other sensory perception systems of the predator and inhibit detection. Escape under the ice edge or into pack ice might also serve the same purpose by confusing the sensory perception of the predator and would also reduce the possibility of visual detection. The use of shallow waters in the face of possible attack by Killer Whales could also be an adaptation to reduce the chance of attack by reducing the overall volume of water that is kept under surveillance for a potential attack (Wells et al. 1980).

The appearance of Narwhals in shallow waters along the shore, when Killer Whales are known to be in the area, appears to be to take advantage of the limited depth characteristics in confusing the

sensory perception of the Killer Whales which may hunt by passive listening (Mate 1975). Similarly, the isolated instances of the occupation of "Z" Lagoon by Narwhals may also be an avoidance response. The lagoon has an underwater landform similar in appearance to the letter "Z" (hence the local name) and may present a natural sonar baffle which would inhibit echolocating capabilities as well as providing a barrier to visual detection. On all three occasions when Narwhals were observed in the lagoon, Killer Whales were present in the adjacent waters of Eclipse Sound and the Narwhals did not leave the lagoon until the Killer Whales had departed. On the first two occasions more than 100 Narwhals were present in the lagoon and on the third occasion only a lone, wounded female was present. We presumed that the female entered the lagoon to escape Killer Whales and attributed her wounds to Killer Whales. The lacerations and tooth marks were not consistent with the tooth or claw marks of a Polar Bear (*Ursus maritimus*) or the bite of a Greenland Shark (*Somniosus microcephalus*), which are both common in the area and known to prey on Narwhals under some circumstances (Beck and Mansfield 1969; Hay 1984). No bears or sharks were observed in the immediate vicinity prior to or subsequent to the event.)

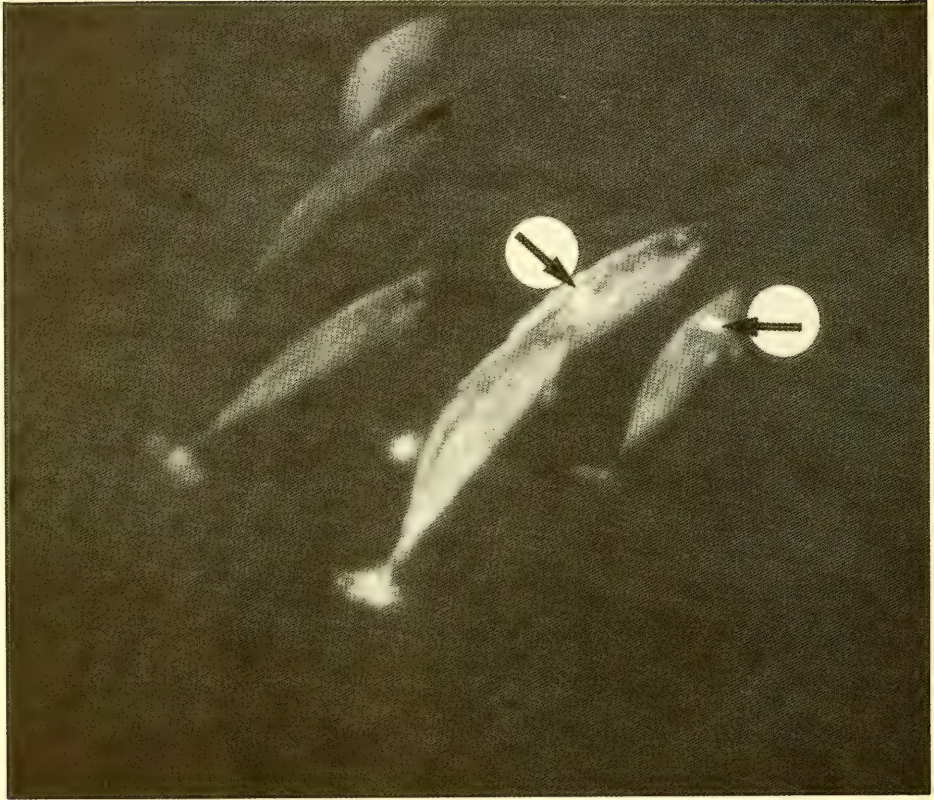


FIGURE 6. Photograph of a pod of seven Narwhals (one below the surface, four females and two juveniles are visible). Many animals bore scars and fresh wounds (arrows), possibly from Killer Whale attacks.

In addition to the obvious masking advantages provided by use of shallow waters, cessation of vocalizations would also be of importance in such a strategy. Cessation of vocalization by Narwhals and seals, in the presence of Killer Whales, as described by Inuit observers (Finley et al. 1984) and Ford et al. (1986) may be a counter strategy for avoidance of detection. Similar reactions to the approach of Killer Whales have been described for Beluga (Schevill 1964). After the initial Killer Whale attacks observed by Ford et al. (1986) on 15 August 1985, subsequent forays on 19 and 20 August did not have the same effect on Narwhal vocalizations. This may seem a contradiction in the defence strategy but it seems that once they are detected Narwhal switch to other defensive behaviours.

Vocalization once detected may serve to confuse the predator by decreasing its ability to focus on

one individual (Norris and Dohl 1980; Wells et al. 1980) and may be important in attracting other Narwhals, thus increasing the collective ability to detect further predators and to provide individual protection within the cover of the group.

Narwhals are social animals and are most frequently observed in small pods; unlike Beluga they do not congregate in large herds (Mansfield 1983). During migration larger groups may be observed, but the pod formation is usually retained with a number of pods loosely associated in a general area. The presence of large numbers of Narwhals in loosely associated pods, as observed in Milne Inlet and Tremblay Sound, may be indicative of such defensive strategies as postulated by Norris and Dohl (1980), providing anonymity in numbers and the collective ability to detect predators on a broad front. Steltner et al. (1984) suggested that Narwhals form larger groups when

attacked by Killer Whales. Norris and Dohl (1980) regarded schooling in cetaceans as an important defence mechanism for the protection of individuals, a form of cover-seeking in the anonymity of the group. This is thought to be the case for fish (Williams 1964) and other schooling animals (Hamilton 1971). Moreover, Norris and Dohl (1980) felt that larger groups or schools may be important for facilitating communication of danger detected by one or more of the members, permitting the group to react as a whole, a phenomenon also observed in schools of fish (Shaw 1970).

Little is known of social interactions among Narwhals (see Hay 1984) and we are not sure of the significance of the tusk lifting which appeared to initiate diving, but similar actions were noted by Finley et al. (1984) on the approach of a ship. It may be that this is an adaptation to assist social integration and to promote cohesion of the pod through synchronous response. Norris and Dohl (1980) have indicated that odontocete behaviour tending towards cohesion involves protection, fright and habitual associations. Such social integration will be dependent upon sensory signals, particularly visual and sound. Synchronous diving in response to a visible threat would be advantageous as an avoidance strategy and it may be that older, adult males are acting as "scouts", alerting the pod on sensing danger, a concept not unknown in odontocetes (Norris and Dohl 1980).

Killer Whales have been suggested as a possible predator on Narwhals (Mansfield et al. 1975; Davis et al. 1980) but have not been thought to have a significant effect on their populations (Davis et al. 1980). However, a small pod of Killer Whales strategically located within the Eclipse Sound area during the late summer could place considerable stress on Narwhals. Lancaster Sound and adjacent waters are noted for their biological productivity. In the late spring and summer, Belugas, Bowhead Whales and Narwhals migrate through the sound to forage and in some cases to bear and nurse their young in the various channels, fiords and inlets to the west, north and south, which are thus critical to their life histories (Dirschl 1982; McLaughlin 1982); they return eastward through the Sound in the fall. Other species such as the Ringed Seal, Bearded Seal (*Erignathus barbatus*), and to some extent, Walrus (*Odobenus rosmarus*) are resident year-round. It is not surprising that Killer Whales also summer in the area, taking advantage of abundant potential prey.

Little is known about the numbers of Killer Whales in the Atlantic (Jonsgard and Lyshoel

1970), let alone the eastern Arctic. Despite published comments on their infrequency in the eastern Arctic (Davis et al. 1980), they are well known to Inuit hunters.

During the period of our observations in August 1985 there may have been 20 to 22 Killer Whales in Eclipse Sound, as the pod described by Ford et al. (1986) appeared to be different in composition from that observed by the authors. Steltner et al. (1984) reported 30 to 40 Killer Whales in Eclipse Sound in 1980. Killer Whales are also recognized as being important predators of the Bowhead Whale in the eastern Arctic, especially along the east coast of Baffin Island (Mitchell and Reeves 1982; Finley et al. 1986). The Killer Whale may prove to be a serious threat to Narwhals in Lancaster Sound during the open water season when 18 000 or more Narwhals (Anonymous 1985; Smith et al. 1985; IWC 1986) may be summering in the bays and fiords adjacent to Lancaster Sound.

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Use of a Net Gun for Capturing White-tailed Deer, *Odocoileus virginianus*, on Anticosti Island, Québec

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Potvin, François, and Laurier Breton. 1988. Use of a net gun for capturing White-tailed Deer, *Odocoileus virginianus*, on Anticosti Island, Québec. *Canadian Field-Naturalist* 102(4): 697–700.

During summers 1986 and 1987 we used a net gun fired from a helicopter to capture White-tailed Deer (*Odocoileus virginianus*) in peat bogs on Anticosti Island. During 90 hours, 142 deer were shot and 98 captured (84 does, 10 bucks, 4 fawns). Only one fatal injury occurred. No mortality was recorded for radio-collared or ear-tagged animals from 1986 (49) in the subsequent six months. Mean chasing time was 2.3 minutes, handling time 4.2 minutes and total time 6.4 minutes. The net gun has many advantages for capturing deer in open areas because it is portable, selective and can be used in any season.

Key Words: White-tailed Deer, *Odocoileus virginianus*, Net gun, capture, Anticosti.

Au cours des étés 1986 et 1987, nous avons utilisé le lance-filet à partir d'un hélicoptère pour capturer le Cerf de Virginie (*Odocoileus virginianus*) dans des tourbières. En 90 heures, nous avons tiré sur 142 cerfs et en avons capturé 98 (84 biches, 10 mâles adultes et 4 faons). Seulement un animal fut blessé mortellement. Les 49 animaux porteurs de collier ou d'étiquette émetteurs en 1986 étaient tous vivants 6 mois après leur libération. Le temps moyen de poursuite fut de 2.3 minutes, le temps de manipulation de 4.2 minutes et le temps total de 6.4 minutes. Le lance-filet offre de nombreux avantages pour la capture du cerf en milieu ouvert: il est facile à transporter à un site, il est sélectif et il peut s'utiliser en toute saison.

Mots clefs: Cerf de Virginie, *Odocoileus virginianus*, Lance-filet, capture, Anticosti.

It is often necessary to capture ungulates for relocation or research purposes, such as marking and telemetry studies. Techniques available include box traps, corral traps, rocket and cannon nets, drive traps or nets, the net gun, snares, and drugs (Rongstad and McCabe 1984). In the course of a research project on Anticosti Island, we needed a technique that would be portable and could be used in summer: the road system is deficient and access is difficult during winter time. Being mostly interested in does, selectivity was also a requirement. The net gun appeared the best potential technique (Barret et al. 1982). Although it has been used successfully on at least six ungulate species (Barret et al. 1982; Andryk et al. 1983; Krausman et al. 1985; Firchow et al. 1986; Gerlach et al. 1986), previous experiences with White-tailed Deer (*Odocoileus virginianus*) have been limited. Barret et al. (1982) captured two deer (fawns) out of six trials, but believed success would improve with more experience. Krausman et al. (1985) made six attempts also and got four deer. Both mentioned difficulties related to the erratic running pattern of the animal and its tendency to search for cover quickly, where they become inaccessible. During summers 1986 and 1987, we were successful in capturing 98 deer with the net gun. This paper reports results from this

experiment and discusses potential use of the net gun for White-tailed Deer.

Study Area and Methods

Anticosti Island (7959 km²), located in the middle of the Gulf of St-Lawrence, is a forested area covered mostly by White Spruce and Black Spruce (*Picea glauca*, *P. mariana*) and Balsam Fir (*Abies balsamea*) [Rowe 1972]. Peat bogs are present throughout the island but are more common in the eastern part. We worked in the western and middle portions in bogs ranging from 5 to 94 ha ($\bar{x}$ = 36 ha). These open areas are used by deer for feeding during summer. Deer density is not known exactly but probably exceeds 15 animals/km², based on aerial survey counts with no correction factor applied for visibility bias (F. Potvin, unpublished).

Between 10–20 July 1986 and 15–22 July 1987, deer were captured with a 4-barrel net gun shooting a 4 × 4 m square net with 18 cm mesh size (Coda Enterprises, Mesa, Arizona). Two helicopters were used in 1986, an Ecureuil (A-Star equivalent) and a Hughes 500D. In 1987, we relied only on the A-Star. The pilot was different each year but the rest of the crew was the same for both trials. The gunner sat on the back floor (door removed) on the same side as the pilot, attached

TABLE 1. Results of using the net gun for capturing deer on Anticosti island.

	Successful	Unsuccessful
Capture attempts	98	44
Adult males	10	4
Adult females	84	33
Fawns	4	7
Shots fired	105	54
Fatal injuries	1	1

with a safety harness. When firing, he could lean out of the helicopter with his feet on a step placed parallel and higher than the skid. The spotter recorder was in front. The crew had no experience with the net gun but was given a one-day training session in 1986.

When a deer was seen in a bog, the helicopter made a low approach trying to keep the animal in the open. Shooting technique was as described by Barret et al. (1982) and Krausman et al. (1985). Some deer located at the edge of the forest were

also slowly pushed towards the bog. Captured animals were ear tagged, fitted with a radio-collar or ear-tag transmitter with mortality option (Lotek Engineering, Aurora, Ontario) and released as soon as possible. Chasing and handling times were recorded to the nearest minute. Chasing time was the elapsed time from initially locating the animal to dropping the first or second net, if necessary. Handling time was the time from capture to release. Pursuits of deer that could not be pushed towards the open after 3-5 minutes were canceled and were not recorded.

Results

Most pursuits were canceled because deer would move swiftly to forest cover or could not be pushed to the open. We shot 142 deer and captured 98 (10 bucks, 84 does, 4 fawns) during 90 hours of work [including cruising time from camp to study area] (Table 1). Quite often, unsuccessful attempts resulted from deer being correctly shot but untangling themselves from the net. Fifteen deer were fired at twice and one three times, eight of these successfully. A higher proportion of the animals shot at were captured in 1987 (81%) than

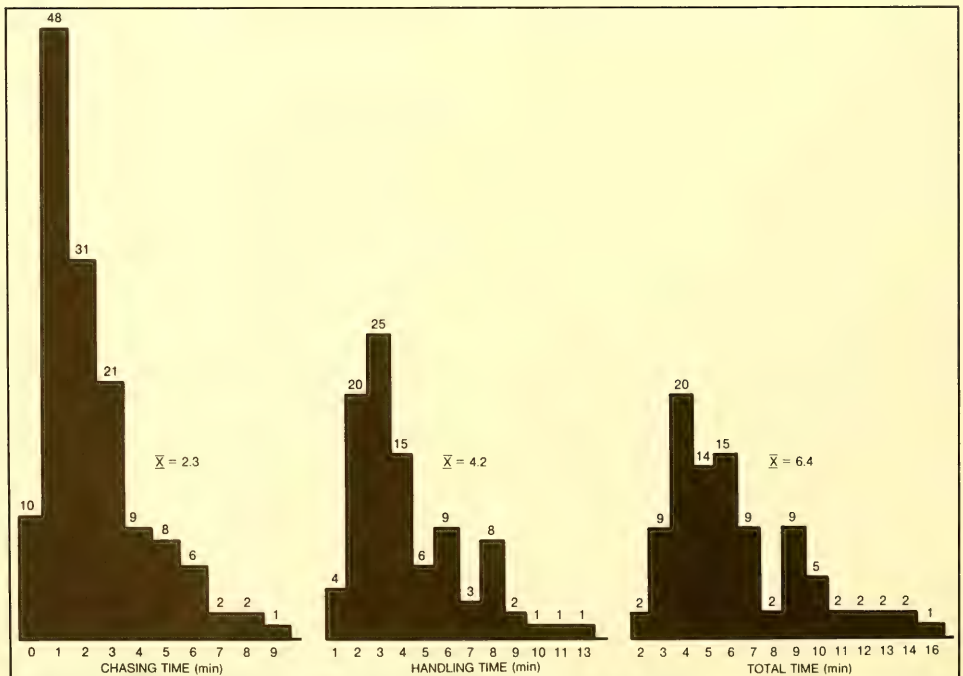


FIGURE 1. Chasing time, handling time and total time recorded for capturing deer on Anticosti island.

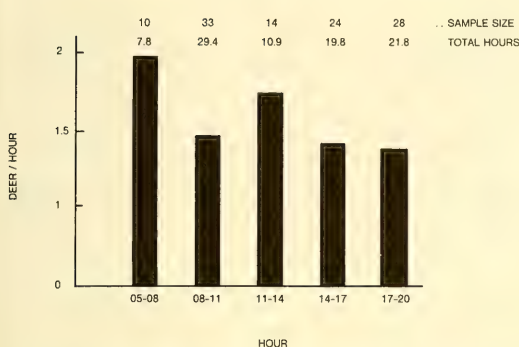


FIGURE 2. Number of deer captured with the net gun on Anticosti island, as related to the period of the day.

in 1986 (61%). Only one fatal injury occurred; a doe had a rear leg broken, either as a result of being hit by a weight of the net, of falling to the ground, or of mishandling. We also suspect that a doe broke or dislocated one of its leg while being pursued. This animal, unfortunately, could not be captured after it moved in the forest. Six of the bucks had antlers in velvet 15 cm or longer. One buck broke one of its antlers while falling in the net at the edge of the forest, but could be released with no subsequent problem. All the captured deer except four yearling bucks and two does were fitted with a radio-collar or ear-tag transmitter. Deer captured in 1986 (49) were located six times from the end of July to mid-January and no mortality was recorded.

Mean chasing time was 2.3 minutes, handling time 4.2 and total time 6.4 minutes (Figure 1). Overall, 90% of the deer were captured and released in 10 minutes or less. Longer chasing times were recorded for deer standing at the border of the forest, not ready to move to the open. Conversely, many animals already in good position were pursued one minute or less. Untangling the net when the deer had fallen in shrub vegetation was responsible for longer handling times. Total time was lower ($P < 0.01$) the second year (5.1 minutes) than in 1986 (7.6 minutes).

Deer were captured from 05:00 h to dusk (Figure 2). Period of the day had no effect on the number of deer shot per hour (Anova test, $P = 0.72$). Deer were as easy to capture in mid-afternoon as in early morning. Lower success for the evening period probably reflects poor light conditions when the sun is low.

Discussion

The net gun proved to be an excellent technique for Anticosti conditions. We captured 98 deer in a

short period of time, which would have been impossible with other methods available. In addition to the cost of the net gun (about \$5000), the most expensive item was the helicopter (\$560/hour for an A-Star, excluding fuel). Cost per animal for this item only (74h overall) was \$423. Despite a lower cost for the Hughes 500D (\$450/hour), we prefer the A-Star because it is more powerful, is easier to shoot from and allows for easier communication between the shooter and the pilot.

While deer behavior poses some problems, as reported previously (Barret et al. 1982; Krausman et al. 1985), we discovered that, with experience, some animals could be driven into the open. Typically, a deer standing near the edge of the forest will hesitate before leaving cover, but if the noise of the helicopter is loud and persistent enough, it will run straight into the open. When chasing a deer, it is important that the machine stays behind the animal so that it runs in a straight line. Only at the right moment when the shooter gives a signal will the helicopter move to the side of the deer to place the shooter in a favorable position for firing.

Our chasing and handling times were very short, being slightly lower than those reported by Krausman et al. (1985) [3.3 and 6.0 minutes, respectively]. This may explain why we had no mortality associated with capture stress. Fatal injury rate was less than 2% of the captures, comparable with that recorded by Palmer et al. (1980) [2.1%, $N = 2035$] and Tierison et al. (1985) [3.2%, $N = 370$] using box traps. Mortality rate with other techniques such as drugs or rocket nets may easily reach 10 or 20% (Hawkins et al. 1967; Palmer et al. 1980).

The net gun has many advantages but its use is limited to open areas. For White-tailed Deer, it may be used in bogs, large fields and probably on lakes during winter time. On the other hand, it needs a trained crew or it may prove hazardous.

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Reproductive Phenology and Early Survivorship in Red-throated Loons, *Gavia stellata*

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Douglas, Sheila D., and T. E. Reimchen. 1988. Reproductive phenology and early survivorship in Red-throated Loons, *Gavia stellata*. Canadian Field-Naturalist 102(4): 701–704.

Red-throated Loons, *Gavia stellata*, occupied breeding territories on the Queen Charlotte Islands, British Columbia, in the middle of April. Eggs were laid between 10 May and 20 July; mean incubation time was 27 d (range 24.5–31 d). Replacement clutches were laid after loss of eggs and after loss of a 4-d old chick. Mean period from hatch to fledge was 48 d (range 46–50 d) with the latest fledging date 14 September. Number of fledged young was 0.86/pair/y (N = 17 nests). Egg mortality was attributed to nest flooding and chick mortality to Bald Eagle, *Haliaeetus leucocephalus*, predation.

Key Words: Red-throated Loon, *Gavia stellata*, reproductive phenology, incubation, pre-fledging, survivorship, Queen Charlotte Islands.

During studies of the breeding biology of Red-throated Loons (*Gavia stellata*) on the Queen Charlotte Islands (Reimchen and Douglas 1984a, 1985; Douglas and Reimchen 1988), we monitored 17 nests for timing and duration of breeding behaviour and for survivorship of eggs and young. The Queen Charlotte Islands [55°N] is at the southerly edge of the species' breeding distribution and, compared to regions north of 70° where ice-free conditions on nesting lakes are relatively short (see Allen 1964), loons can be expected to show a less circumscribed period for breeding. Although the number of nests in this study was small, the data provides a useful comparison with the growing body of information on the species (Bergman and Derksen 1977; Lokki and Eklöf 1984; Schamel and Tracy 1985; Gomersall 1986; Eriksson et al. 1988) at different latitudes and in diverse areas circumboreally.

Study Area and Methods

Nesting waters in the Drizzle Lake Ecological Reserve, Queen Charlotte Islands, included Drizzle Lake, an oligotrophic lake (114 ha; see Reimchen and Douglas 1980 for details), Drizzle inlet, a small stream 4 m wide at its mouth, and shallow ponds (<1 ha) within 1 km of the lake in an area dominated by *Sphagnum* moss. Fourteen clutches were laid in nests at Drizzle Lake and inlet, 8 of these on the shore and 6 on an artificial floating island; 3 clutches were laid in shore nests at two ponds. The 17 clutches represented the reproductive output of a minimum of six different pairs of Red-throated Loons over 10 years (1976–1986). At ten nests, observations were made at least twice a week, at six

nests, every 10 days, and at one nest, the datum is a single observation of two dead chicks.

The floating island (1 m²) consisted of a frame of logs supporting a board platform and bolster of *Sphagnum* moss; polyurethane foam beneath the platform provided additional flotation. It was anchored in water 0.5 m deep near a previous nest site on the lake.

Results and Discussion

Pairs of Red-throated Loons first arrived in breeding territories at Drizzle Lake from 11–19 April (1982–1986). Similarly, on the Shetland Islands [60°N], Scotland, territories are occupied by early April (Bundy 1976). Both areas are in the southern part of the species' breeding distribution, where winter ice is not persistent. In contrast, at nesting areas near the Beaufort Sea [70°], Alaska (Bergman and Derksen 1977) and in Spitsbergen [78°] (Keith 1937), Red-throated Loons did not arrive on territories until June, when nesting ponds are first free of ice.

Timing and duration of incubation and pre-fledging periods is shown in Figure 1. The earliest date for egg-laying was between 10 and 13 May and the latest was 20 July. On the Shetland Islands, the earliest reported clutch was 19 May and the latest, 25 June (Bundy 1976). In the western Canadian arctic and southern Greenland [60°–70°N] (Palmer 1962) and in Novaya Zemlya, USSR [70°–75°N] (Dement'ev and Gladkov 1969), clutches were produced during the first half of June. At those northerly latitudes, timing of first clutches appears to be governed primarily by availability of ice-free conditions.

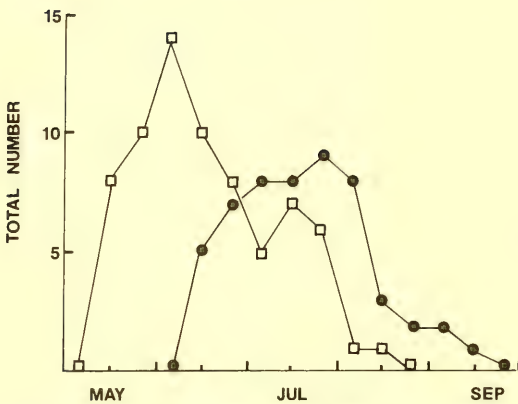


FIGURE 1. Number of eggs (open square) and pre-fledged young (closed circle) at 10-d intervals for 12 nests (1979–1986) at Drizzle Lake Ecological Reserve, Queen Charlotte Islands. Mean incubation period and pre-fledging period is 27 d and 48 d, respectively.

On the Queen Charlotte Islands, early occupation of lakes and early egg-laying may depend on the presence of a territory from the previous year. For example, in 1982, a pair established a territory where there had been no nest for six years, laying eggs on 1 July; in the following year, they returned to the territory and laid a clutch in May. Similarly, in 1983, a second pair laid eggs on 1 July on a newly-established territory, returning the next year to lay the first clutch in May.

All clutches had two eggs; incubation began when the first egg was laid. In four observed clutches, eggs were laid 1 d apart; in one clutch, the second egg was produced 33–45 h after the first. Mean size of eggs measured ($N = 8$) was 72.9 mm by 44.8 mm (ranges 68.2 – 76.7 by 44.1 – 45.5) which is comparable to those from northern Europe and the Soviet Union (Dement'ev and Gladkov 1969; Cramp and Simmons 1977; Furness 1983). Mean incubation time was 27 d (range 24.5 – 31 d, $N = 11$ eggs), similar to incubation periods for Red-throated Loons on the Shetland Islands ($\bar{x} = 27$ d, $N = 17$, Bundy 1976; $\bar{x} = 26$ d, $N = 11$, Furness 1983).

Prolonged incubation of eggs was observed in one clutch, where one egg was incubated for a minimum of 36 d (found floating beside the nest) and the other for a minimum of 57 d (found abandoned in the nest). On the Shetland Islands, a pair incubated infertile eggs for 42 d one year and 47 d the next (Bundy 1976). In Common Loons, which average 29 days incubation (Palmer 1962),

incubation of two eggs for 74 and 68 d, respectively, has been reported (Sutcliffe 1982).

Replacement clutches were laid after loss of eggs in two nests and after loss of a 4-d old chick in one nest. On the Shetland Islands, 64% of lost first clutches were replaced, but there were no instances of replacement clutches after chick loss (Bundy 1976). In western Alaska [66°], replacement clutches were laid in three of four nests 12–15 d after experimental removal of 5-d old eggs (Schamel and Tracy 1985).

The mean period from hatch to fledging was 48 d (range 46–50 d, $N = 5$); on the Shetland Islands, mean fledging time on different islands was 43 d (range 39–48 d; Bundy 1976) and 48 d (range 39–55; Furness 1983). Variation in published fledging times may reflect inconsistencies in what is accepted as “fledging”. In this study, fledging was recognized as the attainment of sustained flight (> 1 min in duration). Chicks on the lake lifted off the water for horizontal distances up to 150 m in the 2 d previous to sustained flight and flew to the ocean within 1 to 4 d after sustained flight capability.

The latest date observed for fledging was 14 September; by this time one of the adults was beginning the molt into basic plumage with replacement of feathers on the side of the neck. In Scotland, an unfledged chick was observed on a breeding lake on 23 September (Booth 1982).

Based on the data from this study, the mean duration from egg-laying to fledging of the young in Red-throated Loons is 75 d. On the Queen Charlotte Islands and in areas at equivalent latitudes, breeding pairs can occupy lakes during at least a 170-d period, a duration long enough for replacement clutch success. In regions north of 70°, where lakes are ice-free for less than about 100 d a year (Allen 1964), re-nesting after a failed clutch or brood may be precluded. At those latitudes, the disadvantage of a shorter breeding season may be counterbalanced by the advantage of longer day lengths for feeding the young.

Yearly number of young fledged per pair of adult loons was 0.86 (Table 1). Fledging success was 0.45 young/pair/y on the Shetland Islands (range 0.36–0.63 on different islands; Gomersall 1986), 0.79 on the Orkney Islands, Scotland (Booth 1982) and 1.2 in Finland (Lokki and Eklöf 1984).

Nine percent of the eggs failed to hatch, 12% died from flooding, and 18% disappeared from nests, presumably from terrestrial predators. Raccoon (*Procyon lotor*), Marten (*Martes americana*), and Black Bear (*Ursus americanus*) on the lake shore in the vicinity of nests, although none have been seen

TABLE 1. Survivorship of Red-throated Loon eggs and pre-fledged young on a floating island and shore nests at Drizzle Lake Ecological Reserve, Queen Charlotte Islands.

	pair-years	eggs laid	Survivorship ¹		Fledged young (no./ pair/y)
			eggs	chicks	
floating island	5	12	0.92	0.64	1.4
shore nests	9	22	0.45	0.50	0.56

¹eggs: eggs hatched/eggs laid; chicks: chicks fledged/eggs hatched

taking eggs. From tracks on the shore, we suspect have been observed that Raccoon (an exotic species on the Queen Charlotte Islands) is the major egg predator.

Twenty-four percent of pre-fledged chicks were taken by Bald Eagles (*Haliaeetus leucocephalus*) and 19% died from unknown causes (three dead beside nest, one missing). Predators on eggs and chicks in this study differed from those observed in other parts of the breeding distribution of Red-throated Loons [gulls, skuas, jaegers and foxes] (Johnson and Johnson 1935; Bundy 1976; Cyrus 1971; Bergman and Derksen 1977; Furness 1983; Schamel and Tracy 1985; Gomersall 1986). None of these groups, except for gulls, occurs on the Queen Charlotte Islands.

Egg survivorship on the floating island was significantly higher than on shore nests (Fisher's Exact Test, $P = 0.018$) but there was no difference in chick survivorship ($P > 0.05$). Greater egg survivorship was partly due to lack of mortality from flooding. In Finland, flooding was a major source of egg death (Lokki and Eklöf 1984) and on the Shetland Islands, 4.5% of eggs were lost in this way (Gomersall 1986). As well, egg survivorship may have been greater on the floating island because island nests have reduced disturbance from terrestrial predators which often use lake shores for travel and foraging routes (Davis 1972; Bergman and Derksen 1977; Lokki and Eklöf 1984).

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The Mystery of the Murres: Thick-billed Murres, *Uria lomvia*, in the Great Lakes Region, 1890–1986.

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Gaston, A. J. 1988. The mystery of the murres: Thick-billed Murres, *Uria lomvia*, in the Great Lakes region, 1890–1986. *Canadian Field-Naturalist* 102(4): 705–711.

During the period 1893–1909 Thick-billed Murres occurred almost annually in the Great Lakes region. Subsequently there have been a few major incursions but none has occurred since 1952. Previous explanations: freezing-over of Hudson Bay, failure of food supplies, and strong onshore winds in the species' wintering area, are examined in the light of present knowledge about the species' movements. I conclude that the incursions were genuine irruptions and that their occurrence must have been associated with changes in the distribution or abundance of the species' prey.

Key Words: Great Lakes, Irruption, Thick-billed Murre, *Uria lomvia*.

The Thick-billed Murre (*Uria lomvia*) is a circumpolar, marine, fish-eating bird that breeds in large numbers in the eastern Canadian Arctic and western Greenland, and in smaller numbers south to the Gulf of St. Lawrence and Newfoundland. In the western North Atlantic the majority winter in continental-shelf waters off Newfoundland and Labrador and Nova Scotia, with only a few occurring regularly off the northeastern United States (Brown 1985).

From time to time the species occurs inland in winter in the vicinity of the Great Lakes and in the northeastern United States, occasionally in large numbers. The origin of the birds involved in such inland records, and the cause of their appearance, have been the subject of some speculation. Fleming (1907), who examined in detail the spate of inland arrivals between 1893 and 1905, believed that the birds originated from Hudson Bay and were driven south by premature freeze-up of their feeding areas. Coues (1897), referring specifically to the wide scattering of records in the eastern United States in December 1896, considered weather to be the prime cause. Tuck (1961) expressed similar views to those of Coues with respect to records in the Great Lakes region in late November and early December 1950, as did Savile (1957), referring to the last big influx in the Ottawa area in 1952. Snyder (1957) described the irregular inland occurrences as "irruptive emigrations", implying a process similar to that governing the periodic occurrence of northern finches and nutcrackers (*Nucifraga*) well south of their normal winter range (Newton 1972, 1985).

Thirty-five years have now elapsed since the last murre invasion of the Great lakes region. Despite the enormous increase in the number of active

observers in North America, only one inland sighting has been reported in *American Birds* since 1952. This fact in itself demands an explanation. Consequently, I have re-opened the question in the light of recent information on the status and movements of Thick-billed Murres. In addition to reviewing the ornithological literature relating to inland records of Thick-billed Murres, I also examined and measured all inland Thick-billed Murre specimens collected from Montreal westwards in the collections of the National Museum of Natural Sciences, Ottawa (NMNS) and the Royal Ontario Museum, Toronto (ROM).

Results

A chronological summary of inland records of Thick-billed Murres, with emphasis on the Great Lakes region, is given in Table 1. The list draws heavily on Fleming (1907) for the period up to 1905.

Date of inland records: Although Thick-billed Murres are present at sea off eastern Canada from at least November to April (Tuck 1961; Brown 1985), their arrivals in the Great Lakes region have been spread over much shorter periods. In years when many appeared, most were seen within a period of 15 days or less (Table 1). Actual arrivals were probably even more synchronized, because in some cases thousands of birds were involved in initial arrivals and, once scattered, such flocks could easily have given rise to all subsequent sightings. In 21 out of 23 years when Thick-billed Murres were recorded around the Great Lakes, the first sightings fell in the period 13 November to 18 December. Very few sightings occurred after 1 January.

The sequence of years in which Thick-billed Murres occurred in the Great Lakes region has not been random, but strongly clumped. Visits

TABLE 1. Chronological summary of inland records of Thick-billed Murres in eastern North America.

1861 (or thereabouts).	One at Hamilton, Ontario (McIlwraith 1894).
1866	Large numbers at Quebec City (W. Couper <i>in</i> Brown 1894).
1889	One at Toronto, 22 May (Specimen in ROM [Royal Ontario Museum, Toronto]).
1890-91	Large numbers at sea off New England in December (Fleming 1907).
1892-93	One shot from a small flock at St. Jean, Quebec on the Richelieu River (Fleming 1907).
1893-94	Large numbers at Montreal, Ottawa, and around Lake Ontario from 19 November to mid-December (Atkinson 1894; Brown 1894; Macoun and Macoun 1909). Last record at Toronto 14 January (Atkinson 1894). A few records in Connecticut (Fleming 1907). The majority of birds reached Toronto 8-10 days after first reaching Montreal (Brown 1894).
1894-95	Birds on Lake Ontario from 8 December. Large numbers at Ottawa from 19-21 December. Scattered records in New York State, Connecticut and Michigan (Fleming 1907).
1895-96	Some on Lake Ontario 9-19 December. Scattered records in New York State (Fleming 1907).
1896-97	Records in the New England states and as far south as Virginia and the Carolinas from mid-December (Coues 1897). Large numbers on Lake Ontario and Lake Erie from 18 December, with stragglers as far west as Michigan and Indiana (Fleming 1907).
1897-98	Large flocks flying upstream at Ottawa on 11-13 December (White 1898; Fleming 1907). Small numbers at Toronto on 14 December and odd records in New York and on Lake Erie (Fleming 1907).
1899-1900	Many in the New England states in the last week of November (Fleming 1907). Specimens from Toronto on 1 December (ROM) and Peterborough, Ontario in late November (NMNS [National Museum of Natural Sciences, Ottawa]).
1900-01	Recorded at Rochester, New York, from 27 November to 2 December and at Toronto on 30 November (Fleming 1907). One specimen from Dunnville, Ontario, on 29 November (NMNS).
1901-02	Large flocks passing Ottawa on 13-15 November (Fleming 1907). One specimen there on 3 December (NMNS). Specimens from Toronto on 16 November and 10 December (ROM). Sightings in New York, Connecticut and Massachusetts in late November and early December.
1902-03	Large numbers at Quebec City, but none on the Great Lakes (Fleming 1907). One at Ottawa on 23 March (NMNS).
1903-04	Large flocks passing Ottawa from 15-21 November (G. R. White <i>in</i> Fleming 1907). Surprisingly, this event was not mentioned by Lloyd (1923). There were no other inland records. White may have made an error in the year.
1907-08	Records at Ottawa on 25 November (Eifrig 1910) and 29 December (Lloyd 1923), at Toronto on 25 November (ROM) and at Point Pelee on 10 December (NMNS).
1908-09	Six were seen on 1 December and 400-500 on 19 December at Ottawa (Eifrig 1910). One at Toronto on 31 December (ROM) and one dead at Lindsay, Ontario, on 29 March (NMNS).
1909-10	One at Ottawa on 11 December (Lloyd 1923).
1914-15	One at London, Ontario, on 10 December (ROM).
1925-26	Several hundred at Ottawa on 7-9 December (Lloyd 1932).
1926-27	One specimen from Arnprior, Ontario, on 18 November (ROM) and several seen on 22 November. First recorded at Ottawa on 25 November. Several hundred present on 1 December (Lloyd 1932).
1932-33	One in North Frontenac County, Ontario, on 15 December (Lindsay 1933). Three specimens from Cap Rouge, Quebec, during 16-27 December (NMNS).
1948-49	One on 8 December and eight on 15 December on Lake Simcoe, Ontario (Devitt 1950).
1950-51	Twenty-two specimens scattered westwards from Montreal, where the first was seen on 26 November (Baillie 1951a) and about 1000 appeared on 27 November (J. D. Cleghorn <i>in</i> Tuck 1961). On 28 November specimens were obtained at Oshawa and Stittsville, Ontario, and on 29 November at Toronto (ROM, NMNS). According to Baillie (1951b) 46 specimens were received by the ROM in Toronto (I found only 16 when I examined the collection). Sightings in Ontario continued up to 5 December, but one was also collected in January 1951 at Ancaster, Ontario, "after a storm" (NMNS). There were two records in Michigan, the first since 1907 (Gunderson 1951a, 1951b).
1951-52	Single specimens from Montreal and Hull, Quebec, on 28 November (NMNS). The coincidence with the date of most specimens from the previous year is a little suspicious.
1952-53	"A flight" occurred at Ottawa in mid-December (Savile 1957). Specimens were collected at Ottawa on 11 December, Carp, Ontario, on 20 December, and Kingston, Ontario, on 21 December (NMNS).
1983-84	One at Derby Hill, New York, on 22 October (Kibbie and Boise 1983).

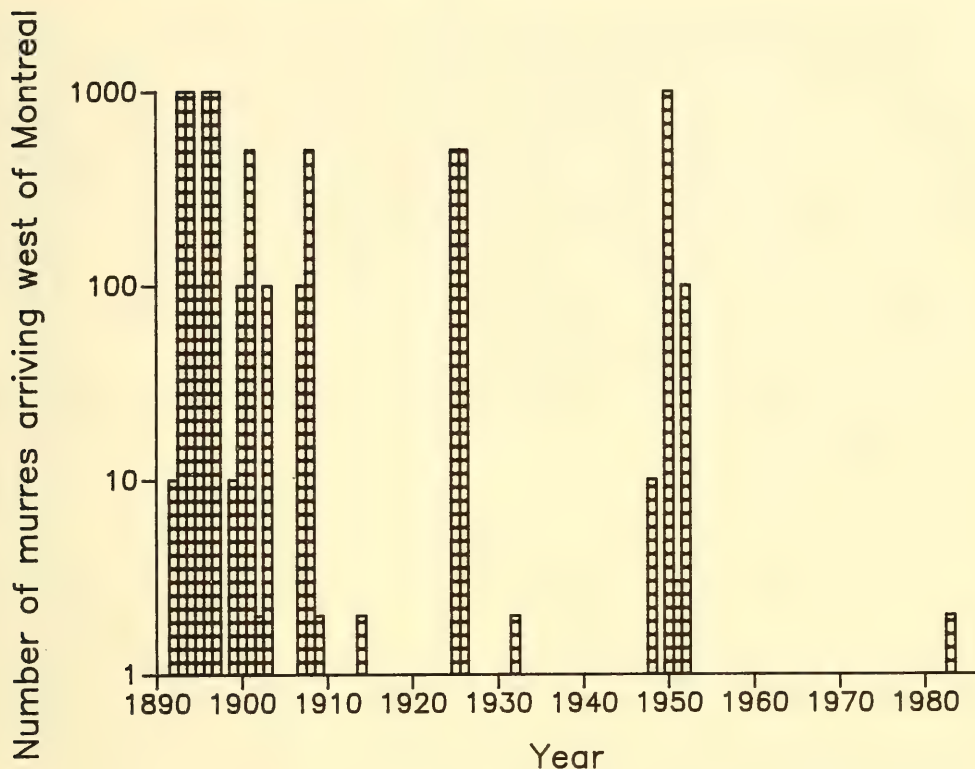


FIGURE 1. Estimates of the minimum numbers of Thick-billed Murres recorded west of Montreal in each winter since 1890.

occurred almost every year from 1892 to 1910, in 1925 and 1926, and again in several years between 1948 and 1953 (Figure 1). A one-sample runs test on years with and without murres between 1890 and 1986 shows the clumping to be highly significant ($z = 4.80$, $P < 0.001$). Prior to 1890 the occurrence of murres inland is somewhat unclear, but the event of 1893 at Toronto was said by an informant of Atkinson's (1894) to be unprecedented in 24 years experience. There was only one substantiated record in Ontario prior to 1890 (McIlwraith 1894).

Bill dimensions and age: Birds in their first winter predominate among those found inland (Brown 1894; Fleming 1907; notes on many specimens examined). I measured bill depth at the gonys and the distance from the nostril to the tip of the upper mandible on all specimens and found that 96% ($N = 83$) of those collected between October and March were first-year birds [according to the criterion of Gaston (1984)].

The mean bill dimensions of inland specimens collected in November and December were smaller

than those of a sample of first-year Thick-billed Murres of unknown origin collected off Newfoundland in November 1981, which were in turn smaller than a sample known to have originated from Coats Island in northern Hudson Bay collected in December of 1984 and 1985 (Table 2). Measurements of breeding birds from Coats Island and elsewhere in Hudson Bay in summer average larger than breeders from High Arctic colonies (Gaston et al. 1983; A. J. Gaston, *unpublished*). In winter adult birds from Coats and Digges Islands, collected off Newfoundland, are also larger in bill dimensions than birds of similar age which originated from Coburg Island, in the High Arctic (A. J. Gaston and R. D. Elliot, *unpublished*). Hence it appears that the majority of birds involved in the inland occurrences were closer in size to those from High Arctic colonies than to those from colonies in northern Hudson Bay.

Movements: Several observers remarked on the flight directions of Thick-billed Murres seen during major inland arrivals. During the event of 1893

TABLE 2. Bill dimensions of specimens collected from Montreal westwards during November and December 1889–1952 and collections of first-year birds made off Newfoundland at the same time of year.

Collection area	Sex	Bill dimension								
		Depth			Culmen			Nostril		
		Mean	s.d.	N	Mean	s.d.	N	Mean	s.d.	N
Great Lakes (November, December)	M	10.8	0.63	29	27.6	1.83	27	24.4	1.43	27
	F	10.7	0.71	37	27.7	1.99	36	24.3	1.66	35
	Combined ¹	10.7	0.68	75	27.7	1.85	72	24.3	1.58	71
Newfoundland (November) ²	M & F	11.0	0.60	14	31.0	3.20	14	25.0	1.70	14
Newfoundland, from Coats Island (December) ³	M & F	11.6	0.59	6	32.9	1.18	6	25.8	1.93	6

¹Includes some birds of unknown sex.²from Gaston (1984).³A. J. Gaston and R. D. Elliot, *unpublished*.

many flocks were seen flying westwards at Montreal and Toronto, leaving little doubt that the movement originated off the east coast (Atkinson 1894; Brown 1894). Likewise, birds seen at Ottawa in 1897, 1901 and 1903 were flying upstream (White 1898; Fleming 1907). In 1893 birds were first seen at Montreal eight days before they were seen at Toronto (Brown 1894), again emphasizing an east-west movement. However, in 1950, when arrivals coincided with gale-force northeast winds, the first record at Toronto was only a day after the first at Montreal (J. D. Cleghorn *in* Tuck 1961).

Weather conditions: Most previous authors have considered weather to be a principal or contributing factor in the arrivals. However, no clear pattern emerges from inspection of the contemporary weather conditions. As documented by Tuck (1961), the arrivals of late November 1950 followed strong NE winds in the Gulf of St. Lawrence. The event was also accompanied by a large wreck of Dovekies (*Alle alle*) in the New England states (Parker et al. 1950) and two reached Toronto (Baillie 1951). Likewise, the large arrival of 1897, which scattered Thick-billed Murres across the entire eastern side of North America, coincided with a fierce storm which created strong NE winds on the coasts of Maine and Atlantic Canada. None of the other major inland arrivals of Thick-billed Murres coincided with abnormally strong NE winds, the most likely conditions to drive birds inland from Atlantic Canada to the Great Lakes. In 1893 the main arrivals on 19 November followed a westerly gale in the Gulf of St. Lawrence and over the Great Lakes. A NE gale occurred on 22 and 23 November, but by that time many birds had already reached Toronto.

In 1894 arrivals began on 19 November, with a second wave about 8 December. A strong W/NNW gale occurred over the whole area on 17 and 18 November, but there were no important weather systems associated with the arrivals in December. Unfortunately weather records are available from only a small number of stations for the period up to 1910. The foregoing notes are taken from the summaries of storms given in Monthly Weather Reviews. No significant storms or gales were clearly associated with the arrivals of 1925 and 1926. The arrivals of 1952, the last major event, followed "several days of light, but sustained, easterly winds" (Savile 1957).

Mean winter temperatures in eastern Canada during the two decades of large arrivals (1890–1910) were similar to those of preceding and subsequent decades (mean December temperatures at Montreal: 1880's, -7.5°C ; 1890's, -6.3°C ; 1900's, -8.2°C ; 1910's, -6.1°C , Exner et al. 1944). For the period 1891–1920 there was no correlation between the numbers recorded west of Montreal ($\log_{10}$ transformed) and the mean November temperatures in their normal wintering areas (Anticosti Island; $r = 0.057$, $N = 30$, NS; St. John's, Newfoundland, $r = -0.155$, $N = 30$, NS). In addition, the occurrence of murres shows no obvious fit to the general climatic trend in eastern Canada since 1880, which has involved an increase in mean temperatures up to the 1950s, followed by a decline up to at least the mid-1970's (Villeneuve 1970; Thomas 1975).

Association with other species: Dovekies, which winter in similar areas to Thick-billed Murres in the western North Atlantic (Brown 1985), are prone to periodic inland "wrecks", usually associated with

gale-force winds (Fisher and Lockley 1954). However, the two most celebrated Dovekie wrecks on the Atlantic coast of North America, in November 1891 and November and December 1932 (Murphy and Vogt 1933) did not coincide with large inland arrivals of Thick-billed Murres. Like the Thick-billed Murres, inland arrivals of Dovekies in North America have been clumped in time. Fisher and Lockley (1954) recorded fifteen winters between 1841 and 1951 when abnormal arrivals were reported in the eastern United States, but five of these occurred in the 1930s.

Discussion

Fleming's (1907) idea that the large flights of Thick-billed Murres arriving on the Great Lakes between 1890 and 1905 had originated in Hudson Bay now appears highly unlikely for several reasons. First, flight directions suggest that the birds came from the east rather than the north. Second, since the account of Lowe, cited by Fleming, there has been little evidence that many Thick-billed Murres winter in Hudson Bay (A. J. Gaston, *unpublished*). Third, measurements suggest that the majority of birds were of High Arctic origin, rather than from colonies in northern Hudson Bay.

Tuck (1961) also dismissed Fleming's explanation. His own conclusion, that the arrivals described by Fleming resulted from birds being blown inland by strong NE winds, does not adequately explain arrivals that took place under other weather conditions, though it may be applicable to the events of 1950, which Tuck described in detail.

Any general explanation for the enigma of the periodic arrivals of Thick-billed Murres on the Great Lakes needs to take into account the following aspects of the phenomenon: (1) the clumping of years with major arrivals, (2) the fact that arrivals usually occurred at about the same date each year, (3) the almost complete absence of adult birds, and (4) the lack of any clear association with wrecks of other seabirds, particularly Dovekies, in most years.

If we accept that Thick-billed Murres arriving in the Great Lakes region in early winter originated from the Gulf of St. Lawrence, or the coasts of Atlantic Canada, then the overwhelming preponderance of first-year birds can be readily explained — most of the birds in the source area at that time of year are indeed in their first winter (R. D. Elliot and A. J. Gaston, *unpublished*). Such birds, by virtue of their inexperience, may be more likely than older birds to stray outside their normal range. Because the birds involved were practically all in their first year, and because most appear to

have died, rather than finding their way back to the sea (Fleming 1907), we can exclude the possibility that the clumping of arrival years resulted from an ephemeral "tradition" whereby certain birds returned over several years to the same wintering area. Likewise, the absence of any clear relationship with weather conditions, or with wrecks of other species, seems to exclude the possibility that the clumping was caused by periodic shifts in climate which brought about runs of years with favourable weather conditions. The scale of the clumping, with runs varying from 1–10 years, seems to resemble a biological, rather than a physical process.

Periodic large-scale displacements of species such as redpolls (*Carduelis flammea*, *C. hornemanni*) and crossbills (*Loxia* spp.) are usually associated with a failure of food-supplies in their normal wintering range (Newton 1972). If a similar failure of food supplies occurred in the Thick-billed Murre's normal winter range, off Newfoundland (Brown 1985), birds may have entered the Gulf of St. Lawrence in larger numbers than usual and spread westwards into the estuary. Once there, some may have continued to move west in search of food, bringing them up the St. Lawrence and Ottawa Rivers and into the Great Lakes. This is in accordance with the fact that birds seen at Montreal and Ottawa frequently were flying west in flocks. The cessation of movements after the middle of December probably occurred because the estuary of the St. Lawrence, and large stretches of the river, begin to freeze over at about that date (Anonymous 1958, 1978).

My own hypothesis concerning the arrival of murres in the Great Lakes region can be summarized as follows: (1) Changes in the distribution and/or abundance of their normal winter food caused birds to disperse farther than usual into the Gulf of St. Lawrence; (2) once there, some birds continued to move west up the St. Lawrence and Ottawa Rivers, sometimes under the influence of NE winds; (3) the movements did not occur once the estuary and the St. Lawrence River had begun to freeze over, hence inland movements took place only during the early part of the winter when most of the birds in the source area were in their first year. I therefore agree with Wintle (*in* Brown 1894), the first observer to comment on the phenomenon, who ascribed the arrival of murres at Toronto in 1893 to a failure of food supplies in their normal winter range. If this hypothesis is correct, Snyder's (1957) description of the movements as "irruptive" was also valid. Similarly, Murphy and Vogt (1933) considered that the wreck

of Dovekies in 1932 must have been partly in response to changes in the availability of food. The lack of coupling between arrivals of Thick-billed Murres and Dovekies is not surprising because the species have different diets (Bradstreet and Brown 1985).

The large numbers of inland and coastal records of Thick-billed Murres in the eastern United States in some winters when they appeared on the Great Lakes suggest that changes in the distribution or abundance of food may have been involved, presumably causing murres also to disperse far to the south of their normal range. Although we can only speculate about what changes in prey stocks might have been responsible for the hypothetical reduction in food available to the murres, it is worth noting that Capelin (*Mallotus villosus*) is an important component of the winter diet off Newfoundland (Tuck 1961). This fish is known to fluctuate greatly in abundance (Carscadden 1984).

The paucity of inland records of Thick-billed Murres since 1952 may be related to declines that have occurred in some of the colonies contributing to the population wintering off eastern Canada. Numbers of Thick-billed Murres breeding in West Greenland have declined substantially over the past 25 years (Evans and Waterston 1975; Evans 1984). Many first-year birds from this population winter off Newfoundland (Salomonsen 1967; Gaston 1980). In addition colonies in the Canadian High Arctic may also have declined since the 1950s (Evans and Nettleship 1985). Birds from these areas are among the earliest to arrive off Newfoundland (A. J. Gaston, D. N. Nettleship and R. D. Elliot, *unpublished*). Reductions in the number of Thick-billed Murres around Newfoundland in early winter may have eased the pressure on food supplies, making irruptive movements less likely to occur. Although the cessation of arrivals on the Great Lakes coincided with the construction of the large dam on the St. Lawrence River near Cornwall, above the junction with the Ottawa River, (completed in 1958; Anonymous 1973), it seems unlikely that these events were connected, because there have been no subsequent records at Montreal or Ottawa either.

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Notes

First Record of the Four-toed Salamander, *Hemidactylium scutatum*, in New Brunswick

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Woodley, S. J., and M. Rosen. 1988. First record of the Four-toed Salamander, *Hemidactylium scutatum*, in New Brunswick. Canadian Field-Naturalist 102(4): 712.

The Four-toed Salamander (*Hemidactylium scutatum*) is documented for the first time in New Brunswick from Fundy National Park. It was found on the boggy margin of a shallow dystrophic lake (Marven Lake) on 2 May 1983.

Key Words: Four-toed Salamander, *Hemidactylium scutatum*, Fundy National Park, New Brunswick.

For Canada, Cook (1984) mapped the Four-toed Salamander's range as including Ontario, Quebec and Nova Scotia. A single New Brunswick locality on his range map is here documented for the first time. In Nova Scotia, the species is recorded on the mainland and on Cape Breton Island. Except in the south-central mainland, most localities are widely separated (Gilhen 1984). Gorham (1970) included the Four-toed Salamander as a hypothetical species in New Brunswick and anticipated that individuals might be located in suitable bog habitats in the province.

On 2 May 1983, during a survey of amphibians and reptiles in Fundy National Park, a Four-toed Salamander (*Hemidactylium scutatum*) was captured near Marven Lake.

Collection was made about 2200 h on a rainy, warm (11°C) evening. Marven Lake is located in the southwest quarter of Fundy National Park. Elevation is 240 m above sea level and the lake is approximately 5 km inland from the Bay of Fundy (45°34', 50°N; 65°05' 80"W). The lake is a shallow dystrophic pond with a mean depth of 1.5 m, an area of 8.2 ha, and a shoreline length of 1000 m. It has a characteristic floating boggy margin of approximately 8-10 m extending between open water and spruce-fir forest. The boggy margin is mainly composed of *Sphagnum* sp. and Leather-leaf (*Chamaedaphne calyculata*) with numerous other characteristic bog plants such as the Pitcher Plant (*Sarracenia purpurea*), Bog Cranberry

(*Vaccinium oxycoccus*), and Rhodora (*Rhododendron canadense*). For approximately 2 m in from the open water, the bog is floating. Dead spruce trees are scattered throughout the bog; many have fallen over and are now lying half-buried in the sphagnum. The salamander we collected was found on one of these logs, about 2 m from open water.

This individual had the characteristic four toes on each hind foot, a pronounced constriction at the base of the tail, and a glossy white belly with prominent black dots. Total weight was 1.1 g, total length was 84 mm and tail length (to constriction) was 48 mm. Its size indicates a female (cf Gilhen 1984) but because it was released at the collection site this can not be verified.

Data from this specimen and documentary colour photographs have been deposited with the National Museum of Natural Sciences, Ottawa.

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A Surgical Procedure for Implanting Radio Transmitters in Striped Skunks, *Mephitis mephitis*

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Rosatte, Richard C., and Paula M. Kelly-Ward. 1988. A surgical procedure for implanting radio transmitters in Striped Skunks, *Mephitis mephitis*. Canadian Field-Naturalist 102(4): 713-715.

Implantable radio transmitters were surgically inserted into the peritoneal cavity of 18 Striped Skunks (*Mephitis mephitis*). The technique provided a feasible mode of monitoring the movements of skunks without the use of conspicuous radio collars.

Key Words: Striped Skunk, *Mephitis mephitis*, telemetry, implant, Ontario.

A radio-telemetry system should not interfere with the normal behaviour of the animal. In two previous studies, Rosatte and Gunson (1984) and Rosatte (1986) encountered problems including neck abrasions or irritations and lost transmitters due to collar slippage when using radio collars on Striped Skunks (*Mephitis mephitis*) in Ontario and Alberta. Juvenile skunks are capable of tripling their weight between July and September and the neck circumference almost doubles during that period (Rosatte, unpublished). This necessitates frequent capture and collar adjustment, a time-consuming activity. If the transmitter could be surgically implanted into the body cavity of skunks, the problem of collar adjustment would be solved.

Implanted transmitters are a relatively recent technological development. Over-wintering survival of White-Footed Mice (*Peromyscus leucopus*) was not reduced by subcutaneous implantable transmitters (Smith and Whitney 1977). However, a subcutaneous transmitter would not be feasible for use in Striped Skunks as the implant package would be too large due to the required battery size for a long-term study (1-2 years). Transmitter packages surgically implanted in the peritoneal cavity have been used successfully in Mink, *Mustela vison* (Eagle et al. 1984), River Otter, *Lutra canadensis* (Reid et al. 1986), and Beaver, *Castor canadensis* (Davis and Von Recum 1986).

Intraperitoneal implants were used to monitor the movements of Striped Skunks in Toronto, Ontario, during 1986. This paper reports the surgical procedure used to implant the transmitter package used in juvenile skunks.

Study Area and Methods

Juvenile Striped Skunks were live-trapped (Tomahawk #105, 106, 108, Tomahawk Live-Trap

Co., Tomahawk, Wisconsin) in an urban area of metropolitan Toronto and transported to the Ontario Ministry of Natural Resources, Research Station, Maple, Ontario, for implantation of radio-telemetry packages (Rosatte et al. 1987). The surgical procedure was performed by the authors in the necropsy room at the research station under aseptic conditions (Archibald 1974). All surgical instruments including implants were submersed in 10% Germiphene solution (E. L. Stickley and Co., Brantford, Ontario) for 24 hrs prior to surgery. Disposable surgical gloves (Becton-Dickinson Inc., Mississauga, Ontario) and masks (Surgical Products, London, Ontario) were worn during surgery.

The implantable transmitters (SMR-1-2) were manufactured by Lotek Engineering Co., Aurora, Ontario. They were covered with plastic tubing and sealed with a biocompatible coating (Elvax, Lotek Engineering Inc.). The implants were cylindrical in shape, measured 7.5 cm ($\pm$ 0.1 cm) in length, 2.0 cm ($\pm$ 0.1) in diameter, and weighed approximately 23 g ($\pm$ 0.56 g) each. The transmitter (151.000-151.400 Mhz)-battery package (1/2 AA lithium thionyl chloride) had an expected minimum life of eight months.

Skunks were anesthetized with an intramuscular injection of ketamine hydrochloride (Parker-Davis, Brockville, Ontario) and xylazine hydrochloride [Rompun] (Bayvet Co., Concord, Ontario) at a 10:1 (ketamine:rompun) ratio. Mean ketamine dosage was 74 mg/kg body weight (range 50-165 mg/kg). Additional doses of 0.5-0.7 ml (100 mg/ml) of ketamine were administered during surgery to maintain anesthesia if the animal exhibited movement of the appendages.

Following anesthesia, skunks were weighed, measured and ear-tagged for identification. Scissors were used to remove hair from an approximately 6 $\times$ 2-cm area posterior to the distal rib on the right

side of the skunk. The area was then scrubbed with bridine surgical solution (A. Glaxo Canada Co., Toronto, Ontario) and covered with a surgical drape. A 3- to 3.5-cm incision (#22 surgical blade and handle, Bard Parker Co., Rutherford, New Jersey) parallel to the distal rib and anterior to the right hind leg was then made through the skin and fatty tissue. After a small puncture was made through the muscle layers and peritoneum with the scalpel blade, scissors were used to complete the incision. The muscle layer was cut approximately 1 cm shorter than the skin incision to allow for more efficient suturing of the extremities of the muscle layer incision.

The implant was inserted into the peritoneal cavity and allowed to float freely in the intestinal cavity (Figure 1). Interrupted sutures (3-0 chromic catgut, 1.3 cm taper needle, Central Sales Co., Brampton, Ontario) spaced 2-3 mm apart were used to close the muscle tissue and peritoneal incision (Archibald 1974). The skin incision was also closed with interrupted sutures (3-0 Ethilon, 1 cm reverse cutting edge needle) placed 2-3 mm apart. Bridine was applied to the incision prior to suturing. Stainless steel suture wire (28 gauge, White Cross Surgical Instrument Ltd., Toronto, Ontario) was used to reinforce the skin suturing on one skunk. Wire sutures were placed approximately 5 mm apart.

The same surgical procedure was used along the linea alba on the ventral surface of one skunk, but the technique was abandoned due to the possibility that rubbing along the stomach area might cause the sutures to break.

The surgical procedure lasted 35-45 minutes. A 0.5-ml intramuscular injection of liquamycin (Rogar STB Inc., Mississauga, Ontario) was administered to combat possible infection due to the surgery [$\bar{x}$ = 38 mg/kg body weight; range 18-69 mg/kg]. Implanted skunks were then placed in live-traps and allowed to recover for 16-24 hrs following surgery, before being released at the original capture site. Water and sardines were provided *ad libitum* during the recovery phase. Attempts were made to recapture implanted skunks to examine the sutures between 1-14 days post-surgery.

Results and Discussion

A total of 18 skunks (17 juveniles: 10 females, 7 males; 1 adult male) received intraperitoneal implant transmitters between July and November, 1986. Two died due to the surgical procedure — one from a ketamine overdose and one due to possible exposure from torn sutures following release at the capture site. Of 15 implanted skunks recaptured between 1-14 days post-surgery, six had to have some degree of suture replacement in the skin incision. Of those checked, only one had any evidence of



FIGURE 1. Implantable transmitter being surgically inserted into the peritoneal cavity of a juvenile Striped Skunk.

post-surgical infection and this was minor inflammation at the site of the incision. Due to the possibility of torn sutures, we recommend a minimum of three stainless steel sutures (28 gauge) to reinforce the skin incision.

The mean weight of juvenile skunks receiving implants was 1.49 kg (0.73–2.73) [July–November]. Therefore the transmitter packages were an average of 1.7% (0.8–3.0) of the animals' total body weight. Mean implant weights of 3.2% of the total body weight of River Otters did not cause any adverse physiological effects as reported by Melquist and Hornocker (1979).

Previous implant studies have noted little or no inhibition of foraging, movement, social activities, and reproductive performance in River Otter and Beaver (Reid et al. 1986; Davis and Von Recum 1984; Melquist and Hornocker 1979). Similarly, the behaviour and movements of skunks in this study were apparently not hampered by the implantable transmitter package.

There are a number of disadvantages in using implantable transmitters for the study of wildlife species. Leakage of body fluids into the transmitter is possible unless the implant is properly sealed. As well, post-operative infections can occur if sterile techniques are not strictly adhered to. Most important is the possibility of alteration of the physiology or behaviour of the animal; in particular, reproductive performance. However, the advantages of the technique clearly outweigh any disadvantages. Premature transmitter-battery package failure due to extreme ambient weather conditions is avoided. As well, there is minimal disruption of the normal behaviour of the animal which may be caused by a cumbersome external radio-collar package. An internal implant package is also more aesthetically compatible as the transmitter is not visible. Most importantly, the implantable transmitter solves the problem of collar slippage or restriction, abrasions, irritations, and the time-consuming process of recapture and collar adjustment due to fluctuation in the animal's body weight.

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The Identity of *Coluber nutkensis* (Reptilia: Serpentes)

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McCoy, C. J., and Oscar A. Flores-Villela. 1988. The identity of *Coluber nutkensis* (Reptilia: Serpentes). Canadian Field-Naturalist 102(4): 716-718.

The identity of *Coluber nutkensis* is discussed. The name originates from a manuscript and painting made on Vancouver Island by members of the Royal Botanical Expedition to New Spain in 1792. The drawing could be of a species of garter snake (*Thamnophis*). The name *Coluber nutkensis* is a *nomen nudum*.

Se discute la identidad de *Coluber nutkensis*, serpiente conocida de un manuscrito y un dibujo hecho durante el viaje a Vancouver Island, que se llevó a cabo por miembros de la Real Expedición Botánica a la Nueva España en 1792. El dibujo puede ser interpretado como perteneciente a una especie de culebra semiacuática del género *Thamnophis*. El nombre *Coluber nutkensis* es un *nomen nudum*.

Key Words: *Coluber nutkensis*, identity, *Thamnophis*, Vancouver Island, British Columbia.

The Royal Botanical Expedition to New Spain, better known as the Sessé and Mociño Expedition, was one of the most ambitious scientific exploration efforts of the eighteenth century. Between 1788 and 1803 explorations and collections were made in Mexico, the Caribbean, northern Central America, and the Pacific Coast of North America (Rickett 1947; McVaugh 1977). In 1792 two naturalists of the Expedition, José Mariano Mociño and José María Maldonado, were ordered by the Conde de Revilla-Gigedo, Viceroy of New Spain, to accompany a naval expeditionary force under command of Captain Juan Francisco de la Bodega y Quadra. The flotilla was sent to the "limits to the north of California" [*La Expedición de Límites al Norte de California*], primarily to resolve territorial disputes with the English on Vancouver Island (Wilson 1970). They reached Nootka Sound, Vancouver Island, on 29 April 1792 and remained there until 21 September 1792 (Wilson 1970).

During his five-month residence at Nootka Sound Mociño studied the history of the region and the ethnology of the Nootka Indians. His report, entitled *Noticias de Nutka*, is a remarkably complete and insightful study that attests to Mociño's scientific acumen. As far as we know *Noticias de Nutka* has been published, in whole or in part, three times (Mociño 1803-1804; Carreño 1913; Wilson 1970), the latter an English translation. Among other results of the expedition were a Nootka-Spanish dictionary compiled by Mociño and a catalogue of plants and animals of the region (Mociño and Maldonado 1792). Expedition artists, including Atanasio Echeverría

y Godoy, also from the Royal Botanical Expedition, prepared sketches of the landscapes and people of Nootka Sound and detailed drawings of local animals and plants.

The catalogue of the biota was deposited in the Spanish government archives in Madrid as part of Bodega y Quadra's report and was not published until 1968 (Arias Divito 1968). It includes a single herpetological entry — *Coluber nutkensis* — which thus takes as authors Mociño and Maldonado in Arias Divito, and date of publication as 1968. *Coluber nutkensis* is a *nomen nudum*. The catalogue was also published as an appendix in Wilson (1970), wherein *Coluber nutkensis* was suggested to be identical to *Coluber constrictor*, a species not known to occur on Vancouver Island (Gregory and Campbell 1984).

Assignment of this overlooked name to a North American snake species would be pure speculation, except for the existence of the Torner Collection of Sessé and Mociño Biological Illustrations in the Hunt Institute for Botanical Documentation. We have been able to assign all but one of the amphibian and reptile illustrations in the Torner Collection to Mexican species (McCoy and Flores-Villela 1985). The unidentified illustration (Figure 1) is of a snake in an undulating posture superimposed on a seaside scene, suggesting aquatic habits. Stylistically the painting is unlike those of the Mexican species, which are uniformly depicted on unadorned backgrounds or are posed on a minimal bit of substrate (McVaugh 1981; McCoy and Flores-Villela 1985). The background shoreline surmounted by buildings, and the rocks, dead tree and other vegetation in the



FIGURE 1. *Coluber nutkensis* (Hunt Institute for Botanical Documentation Accession no. 6331.1262), Nootka Sound, Vancouver Island.

foreground of this painting are characteristic of Nootka Sound paintings by artists of the Bodega y Quadra expedition [see examples in Wilson (1970)]. From these details we conclude that this painting (Hunt Institute accession number 6331.1262) was executed at Nootka Sound and represents the only snake taken there, the species listed by Mociño and Maldonado as *Coluber nutkensis*.

The question remains whether this painting, and thereby *Coluber nutkensis*, can be identified with one of the snake species known to occur on Vancouver Island. The painting is obviously of a colubrid snake, of which three species of *Thamnophis* (*T. elegans*, *T. ordinoides*, *T. sirtalis*) and *Contia tenuis* occur on the island (Gregory and Campbell 1984). The scutellation depicted does not permit identification; the most completely distinct, the ventrals, are too few for any of these species. The elongate head, distinct neck, slender body and attenuate tail suggest *Thamnophis*, but the obscure dorsal pattern without stripes and with dark-edged ventrals resemble the pattern of *Contia*. The alert and possibly swimming posture of the snake in the illustration, the implied seaside habitat, and the

dark-edged ventrals are consistent with identification as *Thamnophis elegans*, a species that inhabits littoral areas elsewhere in British Columbia (Campbell 1969; Gregory 1978). However, Vancouver Island *T. elegans* have a distinct mid-dorsal stripe, and published localities for the species from the west coast of Vancouver Island are all undocumented by actual specimens and are all questionable (P. T. Gregory, personal communication). Although we cannot make a positive identification of the illustrated snake, we suggest that it represents a species of *Thamnophis*, possibly *T. elegans*.

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Breeding Records of the Greater Scaup, *Aythya marila*, in New Brunswick

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McAlpine, Donald F., Scott Makepeace, and Mark Phinney. 1988. Breeding records of the Greater Scaup, *Aythya marila*, in New Brunswick. *Canadian Field-Naturalist* 102(4): 718-719.

First confirmed breeding of the Greater Scaup (*Aythya marila*) in New Brunswick is reported. The 21 nests discovered in 1986 represent the southernmost known breeding for this duck in North America.

Key Words: Greater Scaup, *Aythya marila*, breeding, New Brunswick.

Although Philipp and Bowdish (1917) reported breeding by the Greater Scaup, *Aythya marila*, in New Brunswick (a female seen with small young at Tabusintac), their report has been considered doubtful (American Ornithologist's Union 1983; Squires 1952, 1976). The Greater Scaup breeds almost entirely in the Arctic and subarctic from western Alaska east across the northern Yukon Territory, northwestern, north-central and southern Mackenzie District, southern Keewatin District, Northwest Territories, around Hudson and James bays and in northern Quebec. Casual or irregular breeding has been documented south to southeast-

ern Alaska, northwestern British Columbia, central Manitoba, southeastern Michigan, and in eastern Canada on Anticosti and Magdalen islands and on Newfoundland (American Ornithologist's Union 1983; Godfrey 1986). More recently, single broods of *Aythya marila* were recorded on the Indian River Wildlife Management Area, Prince Edward Island, in both 1980 and 1981 (Maritime Nest Records Scheme, Canadian Wildlife Service, Sackville, New Brunswick). Previously unpublished is a New Brunswick observation made during a Northeastern Wildlife Station waterfowl brood survey in July 1966 of a female with three or four young sighted on

Loder's Creek, Sunbury County (45°54' N, 66°16' W) (Alan Madden, New Brunswick Fish and Wildlife Branch, personal communication to DFM; and University of New Brunswick, Harriet Irving Library and Archives, Northeastern Wildlife Station, Waterfowl brood survey field notes).

Here we report breeding greater Scaup on Grassy Island, Kings County, New Brunswick, a flat treeless, 5-ha island about 600 m offshore in the lower Saint John River (45°31' N, 66°04' W). This is the southernmost known breeding site for the Greater Scaup in North America. Previous breeding records south of the main range have nearly always been in sites with unusually cool environments for their latitude (e.g. small islands in large, cool lakes such as Lake Winnipeg, and islands in areas influenced by cool ocean currents such as Anticosti and the Magdalens). Grassy Island, however, is far enough up the Saint John River to be out of the cooling influence of the Bay of Fundy and successful nesting there, like that on Prince Edward Island, thus appears to be an exception to the general pattern.

In June 1984, SM discovered a single Greater Scaup nest on Grassy Island but did not survey the island further. On 24 June 1986 SM and MP returned to the island and located 10 nests in an incomplete survey. On 25 June 1986 all three of us visited Grassy Island and carried out a survey of the entire island. We located 21 Greater Scaup nests and collected a single clutch of eight eggs with nesting material [NBM (New Brunswick Museum) 6005, NBM 6006]. In nearly all cases we discovered nests by flushing females. Although Squires (1976) reported the Greater Scaup as only casual in New Brunswick in summer, we saw 50 or more of both sexes in the water off Grassy Island as we approached, on 25 June 1986.

The number of eggs in the 21 nests ranged from 1 to 11. The single egg was believed to represent either an abandoned or incomplete nest, as there was no down surrounding it and no female was flushed. Bellrose (1978) noted that Greater Scaups add little down to the nest before incubation. All other nests contained quantities of down. We placed single eggs selected from 10 clutches in water and in only two cases did eggs float; this indicates that the remaining clutches were in the early stages of incubation. Eggs from the collected clutch were all fertile but contained very small embryos. With the single egg excluded, mean clutch size was 8.9 (range 7-11, mode = 9, $N = 20$). Egg weights in the collected clutch ranged from 63.00 g to 70.21 g ($\bar{x} = 67.41$, $N = 8$).

Nests were usually placed in clumps of grasses and forbs among shorter grasses 5-80 m ($\bar{x} = 30.27$ m, $N = 15$) from the shoreline. Birds may have avoided the shoreline due to the absence of suitable grass tussocks. The activity of the approximately 15 cattle placed on the island for summer grazing was also most evident around the perimeter of the island, and this activity may have influenced the placement of nests. Grasses over nests averaged 53.2 cm ($N = 16$) tall but frequently had been grazed down by cattle.

Andrew MacInnis (Ducks Unlimited, Atlantic Region, personal communication to DFM) reported a scaup (sp.?) brood at the Nutter Creek marsh, Kings County (45°35' N, 66°01' W) on 9 August 1985. That site is a floodplain area, 7.4 km upriver from Grassy Island. He also observed six pairs of scaup (sp.?) near Evandale, 8.6 km upriver from Grassy Island on 10 June 1986. These observations suggest that nearby habitat of topography similar to Grassy Island may also harbour nesting Greater Scaup. The area from Upper Musquash Island south to Grassy Island, including Long Island, the Palmer Creek area, Spoon Island, Hog Island and the Mistake Intervale should be surveyed for additional breeding sites.

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Bill Morphology in American Black Ducks, *Anas rubripes*, and Mallards, *A. platyrhynchos*

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Bélanger, L., S. Tremblay, and R. Couture. 1988. Bill morphology in American Black Ducks, *Anas rubripes*, and Mallards, *A. platyrhynchos*. Canadian Field-Naturalist 102(4): 720-722.

Measurements of the American Black Duck and Mallard feeding apparatus were taken on birds killed during the 1984 and 1985 hunting seasons near Lac Saint-Pierre, Québec. We observed no difference in any of the bill or the tongue characteristics of these two forms ($P \geq 0.05$), suggesting that feeding competition may occur when they use the same spatio-temporal dimension of a habitat and if food resources there are limited. Therefore, feeding competition with Mallards in addition to other factors such as hybridization and hunting mortality may influence breeding Black Duck populations in certain areas under particular conditions.

Key Words: American Black Duck, *Anas rubripes*, Mallard, *Anas platyrhynchos*, bill morphology, resource partitioning, food competition.

During recent decades, the status and distribution of the American Black Duck (*Anas rubripes*) and the Mallard (*Anas platyrhynchos*) have considerably changed in eastern North America (Johnsgard 1967; Heusmann 1974; Johnsgard and DiSilvestro 1976; Rogers and Patterson 1984). Originally seen as two distinct taxa (species or subspecies; see Johnsgard 1961) split on an east-west basis, they now occupy large sympatric wintering and breeding habitats. Hybridization is a common phenomena between them (Heusmann 1974; Brodsky and Weatherhead 1984) and recent genetic data have shown that they are in fact two color morphs of a same ancestral species (Ankney et al. 1986). Besides sexual competition for mates, resource competition, particularly for food, may be another aspect of the conflict between these two sympatric forms.

Body size and other morphometric measurements, especially of the feeding apparatus, have been used to predict resource partitioning and ecological niche organization in dabbling ducks (Nudds and Ankney 1982; Pöysä 1983; Nudds and Bowlby 1984; Tremblay and Couture 1986) and in other aquatic birds (Schoener 1965; Lifjeld 1984). The same ecomorphological approach is used here to compare the American Black Duck and the Mallard feeding niche. We hypothesized that the characteristics of their feeding apparatus should be similar, suggesting potential competition for food.

Methods

Measurements of the feeding apparatus of American Black Ducks and Mallards were taken on ducks killed during the waterfowl hunting

seasons of 1984 and 1985 near Lac Saint-Pierre, a natural widening of the St. Lawrence River, 100 km east of Montreal, in south-central Québec. We first estimated the required sample size following the procedures outlined by Elliot (1971: 129) and using bill characteristics (mean and standard deviation) reported for Mallards (Pöysä 1983; Nudds and Bowlby 1984). We calculated that a sample size of at least 20 ducks was required to be within 10% of the mean with 95% confidence. We used the same sample size for American Black Ducks.

Measurements of the different feeding apparatus characteristics (see Tremblay and Couture 1986 for an illustration) were taken with a caliper (± 0.05 mm). Bill length was measured at the lower mandible; bill height and bill width were both measured at the anterior end of the nares. Bill volume was then calculated as suggested by Tremblay and Couture (1986: 2176). We counted the total number of lamellae on the right side of the bill and calculated the lamellar density. We also recorded a series of characteristics of the tongue because that also participate in the filtration and retention of prey (Goodman and Fisher 1962). We counted the total number of marginal lingual papillae or denticles on the left side of the tongue and computed the denticle density. We also counted the total number of bristles and calculated their density. Finally, we determined the total number of pre- and post-papillae of the anterior end of the tongue.

Normality of the variables was tested using the Shapiro-Wilk statistical test, available in the SAS program. For variables not normally distributed, a logarithmic transformation was used. The probabil-

TABLE 1. Characteristics (mean $\pm$ SD) of the feeding apparatus of American Black Ducks (N = 24) and Mallards (N = 21) collected in Lac Saint-Pierre, Québec, 1984-1985.

Feeding Apparatus Characteristic	Black Duck $\bar{x}$ SD	Mallard $\bar{x}$ SD	P*
Bill:			
length (cm)	6.2 $\pm$ 0.3	6.1 $\pm$ 0.4	0.914
width (cm)	2.2 $\pm$ 0.1	2.2 $\pm$ 0.1	0.819
height (cm)	1.7 $\pm$ 0.1	1.7 $\pm$ 0.1	0.808
volume (cm ³)	22.4 $\pm$ 1.1	22.9 $\pm$ 1.1	0.614
total number of lamellae	45.5 $\pm$ 2.5	45.8 $\pm$ 2.0	0.699
lamellae density (number/cm)	7.4 $\pm$ 0.4	7.5 $\pm$ 0.5	0.641
Tongue:			
total number of denticles	5.5 $\pm$ 0.7	5.8 $\pm$ 0.5	0.141
denticle density (number/cm)	3.9 $\pm$ 0.4	3.9 $\pm$ 0.2	0.769
total number of bristles	22.6 $\pm$ 1.6	21.9 $\pm$ 1.3	0.156
bristle density (number/cm)	9.0 $\pm$ 0.8	8.9 $\pm$ 0.8	0.683
total number of papillae	63.9 $\pm$ 7.7	64.4 $\pm$ 8.0	0.930

*Student t-tests were used for all comparisons except for denticle density which was compared using a Wilcoxon two-sample test.

ity level of all statistical tests for accepting the null hypothesis (no difference in the feeding apparatus characteristics of the two forms) was fixed at 0.05.

Results and Discussions

Nudds and Ankney (1982), Nudds and Bowlby (1984), and Tremblay and Couture (1986) have shown that bill length, lamellar density and bill volume were good predictors of the partitioning of the food niche of dabbling ducks. In this study, we found no statistical difference in those bill characteristics used to discriminate the two forms (Discriminant analysis, $n = 43$, Wilks' Lambda = 0.994). None of these features even taken individually was different between American Black Ducks and Mallards (Table 1). Furthermore, despite the fact that their exact roles in food selection is not well defined, tongue features were also not different between the two species (Table 1). Our results suggest that no morphological mechanisms exist to facilitate the partitioning of food resources and that both forms potentially exploit the same food size. Prey size has been said to be a better indicator than invertebrate taxa for comparing the diet overlap between dabbling ducks in relation to feeding competition (Nudds and Bowlby 1984). Moreover, Eadie et al. (1979) found no difference in the foraging behavior of American Black Ducks and Mallards. Therefore, all these results suggest that none of the mechanisms necessary for competitive exclusion of these two forms seems to be present in this case. Feeding competition with Mallards in addition to some other factors such as hybridization and hunting

pressure could thus affect American Black Ducks in some areas, particularly if food resources are limited.

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Deer Mouse, *Peromyscus maniculatus*, in Insular Newfoundland

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Only five specimens of *Peromyscus maniculatus* (Deer Mouse) have been recorded for insular Newfoundland prior to 1986. Forty-four additional specimens are reported here; these document range extension and suggest that *P. maniculatus* may be established in at least the western part of the province.

Key Words: Deer Mouse, *Peromyscus maniculatus*, Newfoundland, range extension.

The island of Newfoundland has a depauperate fauna with only four species of small mammals, *Microtus pennsylvanicus* (Meadow Vole), *Sorex cinereus* (Masked Shrew), *Lepus americanus* (Snowshoe Hare), and *Tamiasciurus hudsonicus* (Red Squirrel), found in any abundance. Of these, only *M. pennsylvanicus* is endemic; *Sorex*, *Lepus*, and *Tamiasciurus* were first introduced to the island in 1958, 1864, and 1963, respectively (Peterson 1966; Northcott 1974; Payne 1976). Eastern Chipmunks (*Tamias striatus*), introduced to the island in 1962 (Northcott et al. 1974), are found in moderate numbers in the Barachois Pond Provincial Park area while Arctic Hare (*Lepus arcticus*) inhabits upland barrens.

On 22 June 1968, a single specimen of the Deer Mouse, *Peromyscus maniculatus*, was captured in extreme southwestern Newfoundland [47°56'N; 59°10'W] (Gould and Pruitt 1969). In December

1981 four Deer Mice were collected at the Abitibi-Price Inc. Woods Camp, Southwest Brook, Newfoundland [48°29'N, 58°01'W] (Bateman 1983). Prior to 1986, no additional specimens had been reported. During research on Marten (*Martes americana*) we captured 44 *P. maniculatus* between 15 May 1986 and 18 July 1987:

Lewaseechjeech Brook (48°37'N; 57°57'W)

-15 May 1986 (adult female containing three embryos)

2.5 km east (uplake) from 15 May capture (48°37'N; 57°55'W)

-19 May 1986 (adult female with swollen mammary glands)

150 m downlake from 19 May capture (48°37'N; 57°55'W)

-31 May 1986 (one, sex undetermined, found dead at red fox den)

Logging camp 185 (48°38'N; 58°09'W)

-19 June 1986 (two males, captured in snap traps by Corner Brook Pulp and Paper personnel)

-20 June 1986 (juvenile male captured in snap trap by Corner Brook Pulp and Paper personnel)

-16 September 1986 (adult male captured in snap trap by Corner Brook Pulp and Paper personnel)

Biggins Brook (48°37'N; 57°51'W)

-20 June 1986 (lactating female)

Marten camp (48°38'N; 57°49'W)

-25 June 1986 (adult male)

-27 June 1986 (adult male)

-28 June 1986 (adult male)

-16 July 1986 (one, sex undetermined)

-27 July 1986 (two, sex undetermined)

-03 September 1986 (adult male)

-06 September 1986 (adult male)

-12 September 1986 (adult male, drowned in water bucket)

-16 September 1986 (adult male)

-19 September 1986 (three males, one female)

-21 September 1986 (one female)

-25 September 1986 (two males)

-26 September 1986 (one male, one female)

-30 September 1986 (one male, one female)

-02 October 1986 (two males)

-04 October 1986 (one male)

-08 October 1986 (two males)

1 km southwest of Biggins Brook (48°36'N; 57°52'W)

-29 June 1986 (adult male)

0.5 km east of Marten camp (48°38'N; 57°49'W)

-03 October 1986 (male killed with stick in garage by Corner Brook Pulp and Paper personnel)

-31 October 1986 (adult male, captured alive in lunch shack by Corner Brook Pulp and Paper personnel, later released)

1 km southeast of Logging camp 185 (48°37'N; 58°09'W)

-15 July 1987 (two, sex undetermined)

-16 July 1987 (two females)

-17 July 1987 (one female, one male)

-18 July 1987 (one female)

The study area ranged in elevation from 150 meters at Lewaseechjech Brook to 375 meters at Marten camp. The predominant vegetation is mature Black Spruce (*Picea mariana*) and Balsam Fir (*Abies balsamea*) interspersed with White Birch (*Betula papyrifera*), and is typical of the mature boreal forest in Newfoundland. Most specimens were captured on well-drained mature forest sites. The specimen collected on 15 May was captured on a grassy area with sandy soil near Lewaseechjech Brook, while the 19 May specimen was captured in a forest edge of Speckled Alder (*Alnus rugosa*) and conifers. Seven specimens collected between 15 and

18 July 1987 were captured in a 13-year old regenerating Balsam Fir cutover.

These captures represent the first documented occurrence of what appears to be an established population of *P. maniculatus*. Its presence on our study site represents a spread in distribution of 41' latitude North and 1°13' longitude East or approximately 180 km NNE of the original discovery in 1968. We have found no information to suggest *P. maniculatus* occupied the island of Newfoundland prior to 1968.

Of the 44 specimens captured, 23 are now at the Newfoundland Museum (NFM MA-35 to MA-52 and MA-62 to MA-66) and two are at the Newfoundland Wildlife Division office in St. John's. Study skins were made of suitable specimens but those badly chewed (by insectivores) were discarded. Identification was confirmed by C. G. van Zyll de Jong, National Museum of Natural Sciences, Ottawa.

Acknowledgments

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Notes on the Birds and Large Mammals of the Upper Blue Goose River Basin, Southwestern Baffin Island, Northwest Territories

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Martin, Jean-Louis, Alex Clamens, and Sylvie Blangy. 1988. Notes on the birds and large mammals of the Upper Blue Goose River Basin, southwestern Baffin Island, Northwest Territories. *Canadian Field-Naturalist* 102(4): 724-725.

Twenty-eight bird and three mammal species were documented from 4 to 18 July 1986.

Key Words: Birds, mammals, Baffin Island, Northwest Territories.

From 4 to 18 July 1986 we visited the upper Blue Goose River Basin, southwestern Baffin Island, Northwest Territories (Figure 1). Our visit was mainly devoted to describing the breeding bird community of this area. The present note reports on the bird and mammal species observed in this area, their frequency of observation, and the breeding status of the birds.

Table 1 lists the observed species with information on their frequency, status and

approximate geographical distribution within the area. Since some arctic species such as raptors are known to show wide fluctuations in abundance, our observations reflect only the situation for 1986.

Most of the bird observations merely confirm what was known for these species in the eastern Canadian Arctic and especially the reports of Soper's expeditions in the area (Soper 1946). The unexpected presence as a breeder on Baffin Island of the Dunlin has been separately reported (Martin

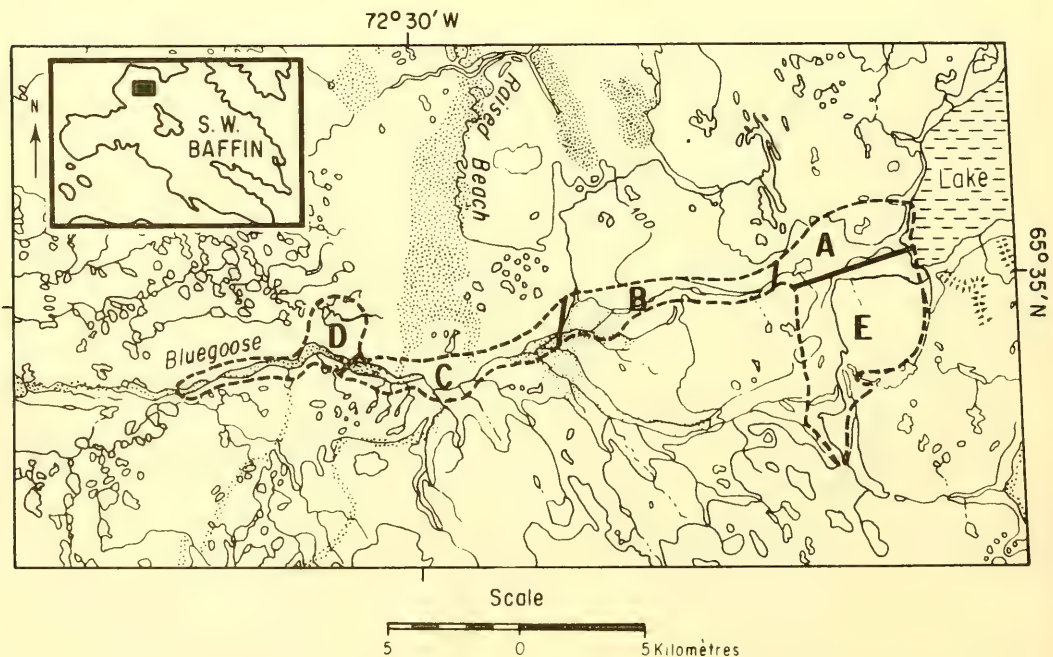


FIGURE 1. Location and schematic representation of the visited area. Letters A to D refer to areas showing approximate location of our observations (see Table 1).

TABLE 1. List of the 28 bird and 3 mammal species observed in the area during our visit in July 1986. Letters A to E refer to the geographical areas defined in Figure 1, column H to main habitat (D = dry flat areas poorly vegetated, L = luxuriant relatively dry tundra, M = marshy tundra, wetlands, S = stony area and small river side cliffs, T = patches of tundra and bare soil, W = widespread), column BS refers to the breeding status (M = moulting area, N = nest found).

Geographical areas:		A			B C		D			B,C A		E			A		H	BS
Species	Day number:	1	2	3	4	5	6	7	8	9	10	11	12	13	14			
<i>Gavia arctica</i> , Arctic Loon			x	x	x	x	x	x	x	x		x	x	x				
<i>Chen caerulescens</i> , Snow Goose		x					x	x	x								M	M
<i>Somateria spectabilis</i> , King Eider			x	x	x	x	x	x	x	x								
<i>Clangula hyemalis</i> , Oldsquaw		x	x	x	x	x	x	x		x			x	x				
<i>Mergus serrator</i> , Red-breasted Merganser						x												
<i>Buteo lagopus</i> , Rough-legged Hawk		x																
<i>Falco rusticolus</i> , Gyrfalcon								x			x							
<i>Lagopus lagopus</i> , Willow Ptarmigan						x	x	x									L	N
<i>Lagopus mutus</i> , Rock Ptarmigan		x	x	x										x			T,S	N
<i>Pluvialis squatarola</i> , Black-bellied Plover								x									M	
<i>Pluvialis dominica</i> , American Golden Plover		x	x		x	x	x	x					x	x			T	N
<i>Calidris canutus</i> , Red Knot															x		D	
<i>Calidris pusilla</i> , Semipalmated Sandpiper								x									M	N
<i>Calidris fuscicollis</i> , White-rumped Sandpiper		x	x	x		x	x	x		x		x	x	x	x		W	N
<i>Calidris bairdii</i> , Baird's Sandpiper						x	x	x	x		x						M	N
<i>Calidris melanotos</i> , Pectoral Sandpiper									x								M	
<i>Calidris maritima</i> , Purple Sandpiper				x													T,S	
<i>Calidris alpina</i> , Dunlin							x	x	x	x	x	x	x				M	N
<i>Phalaropus fulicarius</i> , Red Phalarope		x					x	x	x								M	N
<i>Phalaropus lobatus</i> , Northern Phalarope							x				x			x			T,S	
<i>Stercorarius parasiticus</i> , Parasitic Jaeger								x	x	x								
<i>Stercorarius longicaudus</i> , Long-tailed Jaeger		x	x	x		x			x	x								
<i>Larus argentatus</i> , Herring Gull					x		x				x		x	x	x			
<i>Sterna paradisaea</i> , Arctic Tern		x			x	x					x			x				N
<i>Corvus corax</i> , Raven							x											
<i>Eremophila alpestris</i> , Horned Lark		x							x	x	x						D	
<i>Plectrophenax nivalis</i> , Snow Bunting		x				x			x		x					x	S	N
<i>Calcarius lapponicus</i> , Lapland Longspur		x				x	x				x			x	x		L	N
<i>Canis lupus</i> , Wolf				x			x	x	x	x	x	x	x	x	x			
<i>Alopex lagopus</i> , Arctic Fox							x	x	x									
<i>Rangifer tarandus</i> , Caribou						x		x	x				x	x	x	x		

et al. 1988). Also noteworthy was the almost daily sighting of Wolves. All Wolf observations involved a pair of adults in areas A and E (Figure 1) and a pack of five individuals (two adults and three full-grown young), in areas C and D (Figure 1).

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First Newfoundland Record of the Hoary Bat, *Lasiurus cinereus*, with a Discussion of Other Records of Migratory Tree Bats in Atlantic Canada

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Mauder, John E. 1988. First Newfoundland record of the Hoary Bat, *Lasiurus cinereus*, with a discussion of other records of migratory tree bats in Atlantic Canada. *Canadian Field-Naturalist* 102(4): 726–728.

The Hoary Bat, *Lasiurus cinereus*, is recorded from Newfoundland for the first time. Fifteen New Brunswick and Nova Scotia records have been compiled. The species may be a regular, though rare, visitor or straggler in Canada's Atlantic Provinces. Some of the migratory bats occurring in the northeastern United States or in eastern Canada during late summer and fall may be "drift migrants".

Key Words: Hoary Bat, *Lasiurus cinereus*, migratory bats, new record, Newfoundland, Nova Scotia, New Brunswick, drift migration.

A male Hoary Bat (*Lasiurus cinereus*) discovered alive in a well-treed residential area of St. John's, Newfoundland (47°34'N, 52°43'W) on the morning of 14 August 1984 was the first recorded for the Province. The bat was emaciated, had a badly injured wing, and lived only for a short time. The specimen is now in the collection of the Newfoundland Museum at St. John's (NFM MA-32). Measurements: TL = 103 mm, T = 39 mm, HF = 9 mm, FA = 51 mm, E = 13 mm, WT = 11.9 g.

There is a second Newfoundland record, though it remains unconfirmed; a bat vocalization falling within the range of that of the Hoary Bat was identified using a bat detector at Little Grand Lake, Newfoundland on 29 August 1986 (Joseph Brazil, Newfoundland Wildlife Division; personal communication).

The Hoary Bat, *Lasiurus cinereus*, is the most widespread of all American bats (Shump and Shump 1982). Both the North American subspecies, *L. c. cinereus*, and the South American subspecies, *L. c. villosimus*, are migratory; however the Hawaiian subspecies, *L. c. semotis*, appears to be non-migratory (Findley and Jones 1964).

In North America, the species has been shown to winter in small numbers in California and in the extreme south of the United States, with the main wintering areas believed to be in the Caribbean and in Mexico (Findley and Jones 1964). A northward migration peaks in July (Findley and Jones 1964). Van Zyll de Jong (1985) showed the range of the Hoary Bat in Canada to be south of a line passing through Victoria [British Columbia], Fort Resolution [Northwest Territories], central Manitoba, the southernmost point of James Bay,

and northeastern Nova Scotia; but he stated that delineation of the northern limits of the range in Canada is difficult because the species is rarely seen. There are several extralimital records: Bermuda (Van Gelder and Wingate 1961); Southampton Island [Northwest Territories] (Hitchcock 1943); Iceland (Hayman 1959); Orkney Islands (Barrett-Hamilton 1910); Santo Domingo (United States National Museum catalogue number 105704; Findley and Jones 1964). Mating apparently takes place in the winter range and males and females seem to migrate north separately, with females moving predominantly northeast and males moving predominantly northwest (Findley and Jones 1964). In Canada, the young are born between late May and early July (van Zyll de Jong 1985), when the females are at or near the end of their northward migration.

Records from the eastern part of Canada are relatively few [abbreviations: NBM = New Brunswick Museum; NSM = Nova Scotia Museum]:

NEW BRUNSWICK:

Locality unknown; "uncommon"; (Adams 1873; Chamberlain 1884).

Grand Manan; 1903; (Copeland and Church 1906).

St. Andrew's; 1 ["almost certainly this species", seen in flight]; 26 August 1959; (Gorham and Johnston 1962).

White Head, Grand Manan; 1 male; 24–25 August 1970; NBM 832.

Fredericton; 1 female; 25 August 1970; NBM 904.

Canaby, North Caraquet River; 1; 18 August 1975; NBM 1202.

Saint John; 1 female; 7 September 1975; NBM 1163.

McAdam, York County; 1 female; 12 July 1979; NBM 1696.

Vicinity of Robinsonville; (Christie and McAlpine 1984).

NOVA SCOTIA:

Halifax; 1 adult; 17 November 1909; NSM 17.31.1 (Bleakney 1965).

Dartmouth; 1 adult; 22 October 1917; NSM 17.30.1. Bleakney (1965) states card file at NSM says this is the fourth specimen taken in Nova Scotia.

King's County; believed to have been seen on two occasions during the summer field seasons of 1959–1961 (Bleakney 1965).

Seal Island, Yarmouth County; 1 male; 2 September 1971; NSM 971.329.1.

Halifax; 1 male; 2 November 1980; NSM 980.300.1.

Bon Portage Island; 1 female; 12 October 1985 (Mark Elderkin, Acadia University; personal communication).

There have been no records from Prince Edward Island (Jean Ouellet, Prince Edward Island National Park; personal communication).

The figures in Findley and Jones (1964) suggest that, after a coast-to-coast late spring and summer distribution, there is a split into eastern and western migratory populations for the trip south. The western group recedes southward through the California area, where some remain all winter. The eastern group drifts slowly out of the northeastern United States/eastern Canada region without seeming to move through the southeastern states (an area occupied only during January to May), suggesting an exclusively overwater route south. Hayman (1959) stated that Hoary Bats often migrate south well out to sea. Peterson (1966) noted that the Hoary Bat is a wide-ranging flyer that has been recorded great distances from its mainland range.

Other migratory tree bats have been found at sea as well. Norton (1930) recorded a Red Bat (*Lasiurus borealis*) 385 kilometres east of Cape Cod on 17 August 1929 with no strong winds blowing. Peterson (1970) recorded another individual 145 km south of Yarmouth, Nova Scotia during mid-October 1969 and suggested that it and other Red Bats found at sea in the fall might be involved in migrations. Mackiewicz and Backus (1953) recorded a Silver-haired Bat (*Lasionycteris noctivagans*) and a Red Bat 145–153 km south-southeast of Montauk Point,

Long Island, in August. Carter (1950) recorded about 200 bats (*presumably* all Red Bats — only three were captured) flying around and landing on a ship 104 km offshore in the same general area on 29 September 1949.

Gudmundsson (1957) suspected that the two separate Hoary Bats recorded for Iceland, both in October, were storm-blown while on migration, and that the weather pattern in at least one case supported this supposition. Wind transport likely accounted for the Orkney Islands and Southampton Island records as well. Richardson (1972) discussed radar observations of autumn bird migration in eastern Canada and its direct relation to weather. Tuck (1967, 1968) and McLaren (1981) have shown that “drift migration” (or “reverse migration”) is responsible for unusual fall records of birds in the New England States and eastern Canada. Van Gelder and Wingate (1961) noted a consistent correlation between the arrivals of waves of bats and waves of birds in Bermuda during migration time, with the largest influxes from September to late November. They indicated that both are stragglers blown or “drifted” off the American coast while migrating. Hill and Smith (1984) noted that Hoary Bats, Red Bats, and other migratory bats may travel with migratory birds, or along the same routes used by the birds.

Records of Hoary Bat for Nova Scotia, in particular, tend to be from well after the time that the bulk of the population has moved south. As noted above, Nova Scotia has two late October records and two November records. Other migratory tree bats, particularly the Red Bat, occur quite late in the year in this region as well; Brown (1953) reported a Red Bat at sea off Liverpool, Nova Scotia on 7 October 1952; Hagmeier (1957) reported a Red Bat from New Brunswick on 24 October 1955; as stated above, Peterson (1970) reported a Red Bat from south of Yarmouth in mid-October 1969; and Mark Elderkin (personal communication) captured a Red Bat at Bon Portage Island, Nova Scotia on 8 October 1983. These bats may be just fall wanderers, but it seems more likely that at least some of the northeastern records of migratory tree bats, especially those recorded after mid-September, are the result of “drift migration”. On the other hand, a Silver-haired Bat recorded 19 June 1985 from the French islands of Saint-Pierre et Miquelon, just south of Newfoundland (Desbrosse and Etcheberry 1987), appears simply to have flown beyond its intended destination (see Van Zyll de Jong 1985) during the early-summer northward migration.

Despite the small number of recorded observations, it seems very likely that the Hoary Bat, in particular, is a regular, though probably rare, late summer and fall visitor (or straggler) to the whole Atlantic Provinces region of Canada. Constantine (1966) noted the inconspicuous and often solitary nature of the species, and also the difficulties to be encountered in detecting tree-roosting animals which normally can be viewed only from directly below. Indeed, there have been relatively few observers looking for bats in the region, particularly in Newfoundland. Increased observer activity is likely to produce more bat records. The use of bat detectors would further increase the likelihood of recording this species.

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I would like to express my appreciation for the interest and support of Mike Thomey and Don Barton, who brought the Hoary Bat to my attention, and who helped care for it when it was first found. I also wish to thank Donald McAlpine of the New Brunswick Museum, Barry Wright and Fred Scott of the Nova Scotia Museum, and Mark Elderkin of Acadia University for comments and other assistance including permission to use specimen records.

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Nest Re-use and Egg Burial in the Least Flycatcher, *Empidonax minimus*

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Briskie, James V., and Spencer G. Sealy. 1988. Nest re-use and egg burial in the Least Flycatcher, *Empidonax minimus*. Canadian Field-Naturalist 102(4): 729-731.

Least Flycatchers (*Empidonax minimus*) occasionally re-use old nests within and between years. A single case of clutch burial, in the absence of brood parasitism, may be the result of this tendency.

Key Words: Least Flycatcher, *Empidonax minimus*, nest re-use, egg burial.

Most reports of intraspecific nest re-use by passerines have been largely anecdotal (e.g. Nickell 1957; Allaire 1972; Dexter 1978; but see Shields 1984; Barclay 1988). Mumford (1962) and de Kiriline (1948) noted that Least Flycatchers, *Empidonax minimus*, displayed interest in old nests of other species while selecting their nest sites, but in neither study was an old nest re-used. Goossen (1977) recorded a pair of Least Flycatchers re-using a deserted Yellow Warbler, *Dendroica petechia*, nest approximately five days after the clutch had been preyed upon. In this instance the flycatchers initiated laying even though a single warbler egg remained (Goossen 1977). In this note we present observations on the frequency of intraspecific nest re-use in the Least Flycatcher within and between years. We also report a single case of clutch burial after prolonged incubation and suggest these eggs were buried because of the propensity of Least Flycatchers to re-use old nests.

Study Area and Methods

During 1984 and 1985 we studied Least Flycatchers nesting in the forested dune-ridge that separates Lake Manitoba from Delta Marsh, Manitoba (see MacKenzie 1982 for description of study area). We located nests by daily searching all suitable habitat. Nests were visited every one to three days to monitor their progress (see Briskie 1985 for details). We continued to examine nests which remained intact after predation. In 1985, nests that survived from the previous season were checked for signs of use. New nests in 1985 were removed for measuring after the birds had finished using them and were not available for re-use. Adults were not banded so it was not known if the same pairs re-used their old nests.

Results

During 1984 we monitored 120 nesting attempts. The nests of 34 failed nesting attempts remained

intact and were available for re-use before the breeding season ended but only two nests (5.9%) were re-used that year. Laying was initiated in these nests four and six days after the original clutches had been depredated, respectively. Neither nest was relined or altered. Four young fledged successfully from one nest, but the four young at the other were preyed upon shortly after they hatched. Nests deteriorated rapidly during and after use. Only one nest from 1984 survived to the 1985 breeding season. By 4 June 1985 this nest had been relined and contained a single egg. On 7 June it contained three eggs, but two days later only two eggs remained. The nest was empty when checked again three days later.

One case of egg burial was recorded in 1984. The nest was under construction on 29 May and received the first of four eggs on 4 June. On 1 July, after 24 days of incubation (normal mean incubation period 13.9 days, N = 66; Briskie 1985), the entire clutch was buried under a new lining. The walls of the nest were extended approximately 1-2 cm to form a new cup. The second clutch was initiated on 6 July. Only two eggs were laid, the smallest clutch recorded on the study area (mean clutch size 3.93, N = 152; Briskie 1985). One nestling hatched on 22 July. The second egg was on the ground the next day and showed no discernible embryonic development. By 29 July the single nestling was gone and the nest was collected and deposited in the Western Foundation of Vertebrate Zoology (number 156, 111).

Egg burial was not the only response to extended incubation. In 1985, two clutches of non-viable eggs were incubated for 23 and 25 days before they were deserted. Neither clutch was buried but a new nest of one of the pairs was located approximately 5 m away.

Discussion

Our observations indicate that Least Flycatchers occasionally re-use old nests. Because

most nests deteriorate during and after a nesting attempt, new ones usually must be constructed for the next attempt. Even when an old nest is available, re-use of an old nest entails both risks and benefits. For example, old nests require little investment in time or construction and are advantageous when a bird has recently lost its nest and does not have time to build another nest of its own (Goossen 1977; Finch 1982). By their durability old nests also may indicate a nest-site of high quality. This may be important for species with limited numbers of suitable nest-sites. Conversely, old nests may be less stable or may harbour ectoparasites (Wimberger 1984). Nests already the victims of predation may be especially vulnerable to predators again (Sonerud 1985). Nevertheless, in some situations the benefits of re-using old nests outweigh the potential risks. Since most temperate passerines have only short periods in which to initiate clutches successfully, nest re-use will be advantageous when it reduces the costs of re-nesting to the point that it enables some individuals to initiate an additional breeding attempt.

The Yellow Warbler commonly responds to Brown-headed Cowbird, *Molothrus ater*, parasitism by constructing a new nest or lining over the rejected clutch (Friedmann 1963; Clark and Robertson 1981). Least Flycatchers are not known to bury eggs in response to cowbird parasitism (Briskie and Sealy 1987), although the congeneric Acadian (*E. virescens*) and Willow (*E. trillii*) flycatchers do so occasionally (Walkinshaw 1961). Although host eggs are lost, egg burial is adaptive since it frees a nesting attempt from brood parasitism and reduces the cost of building a new nest (Clark and Robertson 1981). This becomes important as the season advances and the opportunities for breeding progressively diminish (Clark and Robertson 1981).

In contrast, egg burial in the absence of cowbird parasitism is less frequent. Goossen (1985) reported one case of egg burial in 121 nests of the Yellow Warbler, apparently in response to partial predation of the clutch. Similarly, Rothstein (1986) recorded egg burial in the Eastern Phoebe, *Sayornis phoebe*, after experimentally inducing partial clutch loss. In both species new clutches were initiated in the superimposed nests (see also Bendire 1892; Brown 1983).

Regardless of the cause, egg burial is the result of a two-step process. First, a nest and its contents are deserted as a direct result of some disturbance (e.g. brood parasitism, predation). Desertion and re-nesting will be favoured whenever the costs of

continuing with the current clutch exceed the potential benefit from initiating a new clutch. Our observations indicate female Least Flycatchers desert if their clutches do not hatch over a period approximately 10 days longer than normal. Second, given available time, birds will re-nest nearby. Usually a new nest is constructed but an old nest may be reused if it is available and in suitable condition. Egg burial arises as a special case of re-nesting in that the new nest is constructed in the same site as the first one.

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An Observation of a Wild Group of Masked Shrews, *Sorex cinereus*

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Vispo, C. R. 1988. An observation of a wild group of Masked Shrews, *Sorex cinereus*. *Canadian Field-Naturalist* 102(4): 731-733.

A group of Masked Shrews, *Sorex cinereus*, were active together in a mountain forest in Macon County, western North Carolina. A literature review of similar observations and the results of stomach analysis lead to the conclusion that a concentration of prey during a dry spring may have caused the aggregation reported here.

Key Words: Masked Shrew, *Sorex cinereus*, feeding behaviour, social behaviour, diet, North Carolina.

Shrews (Soricidae) are generally reported to be solitary outside the breeding season. Although some sociality has been reported for certain genera (e.g., *Cryptotis* and at least some Crocidurinae), shrews of the genus *Sorex* are considered to be among the least social (Nowak and Paradiso 1983; Michalak 1983; Vogel 1980). I was therefore surprised to encounter a group of *Sorex* active together on a hillside.

On 27 April 1986 an Indiana State University herpetology class walking down a mountain dirt road (elevation about 1400 m) on the property of the Coweeta Hydrological Laboratory, Macon County, North Carolina (35°04'N; 83°23'W), noticed shrews active among fallen leaves on an east-facing roadside bank. It was about an hour before sunset on a hot, clear day of an exceedingly dry spring. A steep bank with mossy rocks and exposed tree roots rose about 2.5 m above a roadside ditch. The bank leveled as it joined the gently sloping forest floor. Most deciduous

vegetation had yet to leaf, and so rhododendron (*Rhododendron* sp.) and a few mountain laurel (*Kalmia latifolia*) were the main foliage. They occurred mostly along the road where they received morning sun. Despite the drought, the area of the shrew concentration contained a damp seep. The leaf litter was mainly oak leaves and, on the flatter ground, was often at least 10 cm deep.

Rustling drew our attention to shrews scurrying up and down the bank. We spread out along about 19 m of the road, and each of us could see at least a few active shrews. This would imply a minimum of perhaps 15 animals, although the common estimate was 30 to 40. The shrews appeared to be mostly small, brown *Sorex* although John Whitaker, Jr., thought he also saw the larger Smoky Shrew, *S. fumeus*. Despite the presence of more concealed trails, the shrews would frequently leap down the banks from higher levels, bounding over the leaves and across rocks or logs. Some darted along well-worn routes through the moss,

running back and forth, often seeming to retrace parts of their paths. Periodically, one would pause before hurrying on.

They sometimes seemed to move in "waves" of two or three animals. The paths of two shrews would occasionally cross, but they did not appear to notice each other; no chasing was seen. High-pitched, faint chirps were heard from at least some of the animals.

At this time, one animal was captured. It was a male Masked Shrew, *S. cinereus*. Its testes were enlarged (mean = 4.4×3.33 mm). A return trip to the site was made on 4, 5 and 6 May; no more shrew activity was seen despite over 18 hours of quiet watching prior to setting traps. The well-worn tunnels in the moss proved to be the regular paths of Southern Red-backed Voles, *Clethrionomys gapperi*, who were visible now and then through the day. Chipmunks, *Tamias striatus*, were frequently heard on the forest floor. Two nights of pit trapping (42 trap-nights) along the hillside yielded five *S. cinereus* (three male, two female), three *S. fumeus* (two male, one female) and one Short-tailed Shrew, *Blarina brevicauda* (a female).

All shrews harbored ectoparasites, most common on the *Sorex* ($n = 9$, including the shrew captured by hand) were pygmephorid mites (*Bakerdania* and *Pygmephorus*, 100% of shrews infested, mean 21.1 per host), ixodid ticks (100% infested, $\bar{x} = 5.8$ per host) and trombiculid mites or chiggers (*Euscheongastia* and *Neotrombicula*, 89% infested, $\bar{x} = 19.2$ per infested host; found mostly just above the tail). Nematodes were present in at least five *Sorex* stomachs.

The reproductive systems indicated that all shrews were breeding adults. One female Masked Shrew possessed six uterine swellings; the Smoky Shrew female had at least seven swellings and was parous. The pit traps also captured three juvenile *Clethrionomys*. Sherman traps (53 trap-nights) caught five adult *Clethrionomys* (three male, two female) and four Deer Mice, *Peromyscus maniculatus* (two male, two female).

There have been previous reports of similar observations of Masked Shrews. Tuttle (1964) reported catching five Masked Shrews on one day from among a vocal group of shrews; many more assumed shrew calls were heard nearby. He observed the shrews to fight upon meeting. Woolfenden (1959) caught three Masked Shrews from another vocal group which he estimated at 20 shrews. Buckner (1970) noted two adult and five juvenile Masked Shrews feeding together on butterflies. The adults pounced on butterflies, and returned to the waiting juveniles which shared in

the meal. Hieshetter (1972) reported a group of Masked Shrews which were causing commotion in leaf litter. He was unsure of total number since no more than three were seen at one time. He also mentioned that a similar observation had been related to him. Along the banks of the Yukon, Cade (1953) commonly saw shrews feeding on insects in the light of the Arctic night, but he does not specifically mention groups. It is possible that some of these were Masked Shrews, however the two specimens identified were Dusky Shrews (*S. obscurus*). Pruitt (1953) snap trapped 26 Masked Shrews during six nights (= 600 trap-nights) in a bog habitat; 16 of these were taken on the third night. This could indicate a burst of shrew activity, but Pruitt believed a high shrew catch during the first two nights was prevented by squirrel and Raccoon disturbance to the traps.

In Eurasia, the general works of Ognev (1962) and Hainard (1961) mention groups of the Common Shrew, *S. araneus*. Crowcroft (1957) commented specifically on such observations and reported his own. He warned that it is very easy to over-estimate numbers, since the animals move so quickly and pass in and out of view. In a group that he watched, his first impression was of "dozens" of shrews but observation convinced him that only six to nine were actually present. Another similar revised estimate had been described to him. The shrews which Crowcroft watched were "squeaking and fighting", and after seeing the activity ebb, he concluded that a single shrew family had been attacking an intruder. Ognev's (1962) comments are also of fighting groups, although he associated this with breeding.

Baker (1983) believed such groups might be "attracted to a food source or perhaps involved in a courtship ritual". In the observations reported here, I feel the former to be likely. Many sciarid (Diptera) larvae were found in the shrew stomachs. The shrew captured by hand had a chironomid larva in its clenched jaws, but its stomach contained over 90 sciarid larvae which amounted to almost 100% of the food volume. Two of the *Sorex* had empty stomachs and in the six remaining, sciarid larvae composed about 65, 40, 30, 20, 10 and 0% of the food volume (mean = 28%). The stomach of the *Blarina* was full of these larvae and contained over 150 individuals.

For comparison, Whitaker et al. (1975) reported that identifiable dipteran larvae composed less than 1% of the food of Smoky and Masked shrews ($n = 16$) taken during April in an adjacent county over a three-year period; they noted no unusual shrew densities. Cole and Schlinger (1969) and

Imms (1964) mention that the larvae of some sciarids may travel in long, snake-like masses over the forest floor. While such concentrations were not seen by us at the time, lesser concentrations could have gone unnoticed in the leaf litter.

None of us observed battling between the shrews, and the calling we heard seemed (although we were not unanimous) to fit better Blossom's (1932) description of the Masked Shrew's feeding call, "a succession of faint twittering notes", than his "rapid series of rather staccato squeaks" heard during aggression. Torn ears on a couple of the collected shrews could indicate past altercations. The fact that Smoky Shrews were apparently present as well makes a breeding aggregation seem less probable. Tuttle (1964) also reported seeing a Smoky Shrew during his observations.

Repeated reports of groups of Masked Shrews might indicate that such behaviour is regular if rare. In the case discussed here, it seems likely that a prey source may have brought together these predators. Perhaps the drought conditions concentrated available food in the area of the seep; Verme (1958) similarly suggested that a dry summer may have resulted in unusual shrew densities. Our results seem to show that, perhaps because of food distribution, adult Masked Shrews may be socially tolerant outside the mating bond. However, observations detailed by others indicate that gatherings are sometimes associated with aggression. If future witnesses of shrew groups could capture a few specimens and examine their stomach contents, some of the conclusions could be further tested. I would appreciate hearing from anyone who has had a similar experience.

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Egg Retention by a Snapping Turtle, *Chelydra serpentina*, in Central Ontario

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Galbraith, David A., Cynthia J. Graesser, and Ronald J. Brooks. 1988. Egg retention by a Snapping Turtle, *Chelydra serpentina*, in central Ontario. *Canadian Field-Naturalist* 102(4): 734.

A road-killed gravid Snapping Turtle (*Chelydra serpentina*) was found on 4 August 1985, near Haliburton, Ontario, a month later than nesting concluded throughout the province that year. One of 14 intact eggs from this turtle hatched after 76 days of incubation at room temperature. Egg retention in the uterus appears to be rare in Snapping Turtles, and is not likely adaptive.

Key Words: Snapping Turtle, *Chelydra serpentina*, egg retention, road-kill, Haliburton.

Temperate climates place severe restrictions on the timing of nesting by reptiles, particularly if their eggs require a substantial time to develop. In central Ontario, Snapping Turtle (*Chelydra serpentina*) hatchlings almost never survive in the nest over winter (Obbard and Brooks 1979), although farther south hatchlings may remain underground as an overwintering strategy (Gibbons and Nelson 1978). The short summers and apparent inability to overwinter in the nest implies strong selection against late nesting in northern populations of turtles. Here we report the finding of a gravid Snapping Turtle in Ontario in August, well past the usual nesting period for this species.

On the evening of 4 August 1985, a mortally injured adult female Snapping Turtle was found on a highway near the town of Haliburton (45°05'N; 78°30'W). The turtle appeared to have been struck on the carapace, exposing the pleuroperitoneal cavity. The oviducts had been ruptured and eggs were visible within the coelom. The eggs appeared to be normally shelled, and 14 intact eggs were removed from the turtle for incubation. Several more broken eggs were visible. The ovaries were not examined for corpora lutea.

The collected eggs were incubated in moist soil maintained at room temperature. Most eggs developed a fungal infection and were apparently infertile when collected. A single hatchling emerged on 25 October 1985.

A wide variety of turtle species may retain eggs for days or weeks if nesting conditions are not optimum (Moll 1979). However, these species lay multiple clutches in single years, whereas Snapping Turtles do not (Congdon et al. 1987). Egg retention or late nesting by Snapping Turtles has been reported occasionally (Agassiz 1857; Weber 1928). However, in a long-term study of reproduction of Snapping Turtles in Algonquin Park, 60 km north-east of Haliburton, no turtle has nested later than the first week of July in the 16 seasons since observation

began in 1972 (R. J. Brooks, *unpublished*). In a similar study in Michigan, no Snapping Turtles nested later than 28 June between 1976 and 1983 (Congdon et al. 1987). It is therefore unlikely that long-term retention of shelled eggs *in utero* by Snapping Turtles in northern populations is a viable reproductive strategy. Egg retention in such cases may be the result of pathological or other atypical influences on the timing of ovulation and oviposition.

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Some Aspects of the Ecology of the American Brook Lamprey, *Lampetra appendix*, in the Mashpee River, Cape Cod, Massachusetts

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Hoff, James G. 1988. Some aspects of the ecology of the American Brook Lamprey, *Lampetra appendix*, in the Mashpee River, Cape Cod, Massachusetts. Canadian Field-Naturalist 102(4): 735-737.

Adult American Brook Lamprey were collected or observed in the Mashpee River in April and May 1986 and 1987. These are the first records of adults from coastal Massachusetts. Specimens are smaller than those reported from other parts of the range of the species.

Key Words: American Brook Lamprey, *Lampetra appendix*, reproduction biology, first record, Massachusetts.

The American Brook Lamprey, *Lampetra appendix*, is a nonparasitic freshwater fish which, along the Atlantic coast, is distributed from Virginia to New Hampshire (Rohde 1980). American Brook Lamprey ammocoetes have recently been recorded from three drainages in Suffolk County, Long Island (Schmidt and Smith 1984). Here, I report on the first adults recorded from the Mashpee River on Cape Cod, Massachusetts (41°31'N; 70°29'W), and on their biology there.

The Mashpee River originates from the Mashpee-Wakeby Ponds. It is a narrow, shallow brook with a length of approximately 6.5 km. Along its course to Popponesset Bay and Nantucket Sound it is fed by numerous springs. Approximately 1.5 km of its lower reaches is under tidal influence.

Alewife, *Alosa pseudoharengus*, and Blueback Herring, *A. aestivalis*, ascend the Mashpee in the spring to spawn in the Mashpee-Wakeby Ponds. Other members of the fish community include the Mummichog, *Fundulus heteroclitus*; Banded Killifish, *F. diaphanus*; Fourspine Stickleback, *Apeltes quadracus*; Ninespine Stickleback, *Pungitius pungitius*; American Eel, *Anguilla rostrata*; White Sucker, *Catostomus commersoni*; Brook Trout, *Salvelinus fontinalis*; Brown Trout, *Salmo trutta*; and Sea Lamprey, *Petromyzon marinus*.

In contrast to many Cape Cod streams, the Mashpee is relatively free from cranberry culture. Apart from a few small bogs and the lower tidal area, the stream flows through typical Cape Cod terrain of scrub oak and pine vegetation.

I first observed adult American Brook Lampreys on redds in the Mashpee River in late April 1966. Over the next 20 years, I recorded

adults on three different occasions from April to early May. On 2 May 1986, I collected seven spent individuals (five females and two males). This collection was made from a freshwater tidal redd and is the only adult sample for coastal Massachusetts (voucher specimens are deposited in Southeastern Massachusetts University). It also appears to be the first record for this species in tidal waters. K. E. Hartel, Harvard University and Massachusetts Division of Fisheries and Wildlife, collected ammocoetes belonging to the genus *Lampetra* from the upper Mashpee River in 1980 (Museum of Comparative Zoology Collection Numbers 056845, 056847, and 057866). These records were mapped by Rohde (1980).

The Massachusetts Division of Fisheries and Wildlife have recently placed this species on the state list of threatened species. Because of its status, I made no collections in 1987.

There is surprisingly little information on this species' spawning biology. Vladykov (1949) reported a peak in spawning activity in Quebec from mid May to early June at a water temperature of 17°C. Rohde et al. (1976) observed American Brook Lampreys on spawning redds from 28 March to 4 April in Delaware at water temperatures ranging from 6.8-12.0°C, dissolved oxygen from 9.4-12.5 ppm and pH from 6.7-7.0. I had under observation four spawning groups from 22 April to 1 May 1987. The water temperature was 10-11°C, dissolved oxygen 10.5-10.9 ppm and the pH ranged from 5.9-6.2.

Vladykov (1949) described the nest as a shallow pit. Scott and Crossman (1973) characterized it as a shallow gravel-filled pocket, less than 305 mm in diameter, and located between large, round stones. Rohde et al. (1976) mentioned only that redds are larger than that of the Least Brook Lamprey,

Lampetra aepyptera, for which the diameter ranges between 150–220 mm. The four nests I observed were oval to circular in outline and while the margins were difficult to discern I recorded each to be within 100–150 mm in diameter. Young and Cole (1900) recorded that groups of lampreys of up to three or four dozen spawn in an area of a few square meters and that 3–25 individuals are found in a single nest. I found three nests above the fall line, each approximately three meters apart, located in less than 25 cm water depth. The redds contained from three to nine individuals. Redds in the Mashpee River are depressions of approximately 25 mm and are located in clear, flowing water and their construction is more gravelly than the surrounding sandy substrate. Young and Cole (1900) reported that males outnumber females on the redds 5:1. In my 1986 collection, the females outnumbered the males 5:2.

In analyzing the specimens from the 1986 collection, I found that the spawning adults from Massachusetts are smaller than those from other parts of the range of the species. Mashpee River specimens ranged from 100–109 mm (mean 104, $n = 7$). Weights ranged from 1.40–1.93 g (mean 1.79 g). Rohde et al. (1976) reported spawning specimens from Delaware ranged from 103–149 mm (mean 126.6, $n = 26$). Branson (1970) recorded that Kentucky individuals, all males collected in early March, ranged from 138–165 mm (mean 150.8, $n = 5$). Manion and Purvis (1971) gave lengths of 111–196 mm (mean 154.0, $n = 375$) for spawning specimens from Lakes Superior and Huron. Vladyskov (1951) presented lengths of 116–158 mm (mean 143.0, $n = 10$) for Quebec spawning specimens. Kott (1974) recorded lengths from 161–217 mm (mean 188.0, $n = 457$) for Ontario spawning individuals. Sawyer (1960) reported lengths in New Hampshire to range from 106–132 mm (mean 115.6, $n = 13$). Spawning adults from New Hampshire, while slightly over 10 percent longer, were closest in length to those in my Massachusetts collection.

It is generally assumed that all lamprey are fed on by many fishes, especially trout which cohabit the cool, clean streams (Scott and Crossman 1973). Over the last twenty years, I have analyzed the stomachs of several hundred Brook Trout, *Salvelinus fontinalis*, and Brown Trout, *Salmo trutta*, from the Mashpee River. On only one occasion did I find a lamprey ammocoete. This individual was in a Brook Trout of approximately 200 mm in length. It is not known whether this is due to the rarity of the prey or to the dietary

preference of the predator. It is noteworthy that I have observed on several occasions trout (200–250 mm in length) situated for approximately 30 minutes within 25 cm of lamprey redds.

Hardisty and Potter (1971) discuss our lack of understanding of the role lampreys play in stream ecology. Vladyskov (1973) suggests that we should protect all nonparasitic lampreys. The Mashpee River population is unique in its diminutive size and seems to be unique in sometimes being a tidal spawner. I suggest that the current protection be maintained.

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Shrubby Evening Primrose, *Calylophus serrulatus*, Adventive in Wellington County, Ontario

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The occurrence of Shrubby Evening Primrose in Wellington County represents the most easterly location for this species in North America.

Key Words: Shrubby Evening Primrose, *Calylophus serrulatus*, *Oenothera serrulata*, eastern range extension, Ontario.

Calylophus serrulatus (Nutt.) Raven, Shrubby Evening Primrose, has long been known as *Oenothera serrulata* Nutt. and is referred to under that name in both Gleason and Cronquist (1963) and Scoggan (1978). Raven (1964) made the revision to *Calylophus serrulatus* and this was adopted by Voss (1985).

This species has been recorded in Ontario in Lambton County (Dodge 1914) and in Thunder Bay (Hartley 1968). It also occurs at one location in Michigan (Sleeping Bear Dunes) and is presumed to be adventive at this location (Voss 1985). Shrubby Evening Primrose is a wide ranging species found in Alberta and more commonly in southern Saskatchewan and Manitoba in Canada. In the United States it is common in the central states and extends south into southern Texas and at one location in Mexico (Towner 1977).

On 5 June 1984, while collecting some common adventive species on a seldom used Canadian Pacific railway embankment in Puslinch Township, Wellington County (43°31'N; 80°08'W), a number of plants of Shrubby Evening Primrose were seen. On a closer search of the area, 50 plants were found ranging in size from single-stemmed plants 15 cm in height to ones 60 cm high with many branched stems. This species is the only

shrubby member of the Evening Primrose family (Onograceae) in Ontario, the stems on the older specimens being persistent up to 30 cm at this site. These plants were scattered along 50 m of steep west facing bank in sandy gravel soil where they were growing in association with Dropseed (*Sporobolus cryptandrus*), Cinquefoils (*Potentilla*



FIGURE 1. Shrubby Evening Primrose, *Calylophus serrulatus*, photographed in Puslinch Township, Wellington County, Ontario.

argentea) and (*P. recta*), Common St. John's Wort (*Hypericum perforatum*), Wild Carrot (*Daucus carota*), Blue Weed (*Echium vulgare*), Common Mullein (*Verbascum thapsus*), Dwarf Snapdragon (*Chaenorhinum minus*), Black-eyed Susan (*Rudbeckia hirta*), Common Yarrow (*Achillea millefolium*), Gray Goldenrod (*Solidago nemoralis*) and Hawkweed (*Hieracium floribundum*).

This site was revisited each June 1985–1987 and seedlings were observed. In 1987 the plants numbered over 1000 and had spread over 200 m of the embankment. The plants are difficult to spot because their yellow flowers blend in with the Cinquifolios and St. John's Wort. On closer inspection, their 4-petaled rather than 5-petaled flowers as well as their vegetative characteristics help to distinguish them from these other three similar yellow-flowered species at this site. This location is the most easterly in North America. As Shrubby Evening Primrose is obviously thriving here it might occur in similar situations in southwestern Ontario.

Specimens are deposited at OAC (70340), DAO (444519), CAN and WAT.

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Surplus Killing of Eared Grebes, *Podiceps nigricollis*, by Mink, *Mustela vison*, in Central British Columbia

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Breauult, Andre M., and Kimberly M. Cheng. 1988. Surplus killing of Eared Grebes, *Podiceps nigricollis*, by Mink, *Mustela vison*, in central British Columbia. *Canadian Field-Naturalist* 102(4): 738–739.

Fifty breeding Eared Grebes (*Podiceps nigricollis*) and one American Coot (*Fulica americana*) were found dead on their nests near Springhouse, British Columbia, in 1986. Carcass analyses suggested that Mink (*Mustela vison*) were responsible for the killing. This appears to be the first reported instance of surplus killing of waterfowl by Mink in the wild.

Key Words: Eared Grebe, *Podiceps nigricollis*, Mink, *Mustela vison*, surplus killing, British Columbia.

Surplus killing occurs when a predator kills more prey than it can consume at the time of killing (Kruuk 1972). Victims of surplus killing are often captive, or captive-reared and released, animals (Sargeant et al. 1973). Observations of surplus killing under natural conditions are rare. The few known cases involve easily accessible prey species such as ungulate herds or colonial nesting birds, which are part of the predator's usual diet (Kruuk 1972).

In this note, we document a case of surplus killing of Eared Grebes (*Podiceps nigricollis*) in a colony on Westwick Lake, 20 km southwest of Williams Lake, British Columbia (51°59'N; 122°09'W).

Westwick Lake is 2 km long and varies in width from 30 to 400 m. This 52-ha lake supported two Eared Grebe colonies of about 100 pairs each in 1986. Colony A was located at the southeast end of the lake in a sparse patch of *Scirpus* about 50 m from shore. Colony B was located in the narrow

portion of the lake, in denser *Scirpus*, 8–10 m from shore and 600 m from Colony A.

We visited the colonies for the first time in 1986 on 16 June and found 39 adult Eared Grebes dead on their nests in Colony B. Killing was judged to have occurred within the previous 3 days, because it takes 3–4 days for maggots to develop on fresh carcasses (Putman 1983). About 150 live adults were present in and around Colony B. On 18 June, we searched the area along the lakeshore. No other marsh-nesting species seemed to be affected, although American Coot (*Fulica americana*) and Ruddy Duck (*Oxyura jamaicensis*) nests were located near the colony. The grebes nesting in Colony A were not affected. Both colonies were visited regularly in the following two months, and 11 more casualties were recorded in Colony B over this period. Only one individual of another species was found killed, an American Coot which nested 3 m from the east end of Colony B. Three days after the first visit, new nests were found in Colony B. No new nests were found later in Colony A, suggesting that the grebes in Colony B that lost their mates paired again and renested there, instead of moving elsewhere to breed.

Twenty-four fresh Eared Grebe carcasses were collected, frozen and brought back to the University of British Columbia, Vancouver, B.C., for autopsy. Examination of the heads revealed small round punctures on the skull and neck of all specimens. In some cases, the skull was partly crushed. The size distribution of the puncture marks suggested that Mink (*Mustela vison*) was the predator. By comparing puncture marks with Mink skulls, we concluded that the killing had probably been done by a young adult. If the killing was carried out by more than one individual, the predators were very similar in size.

Although Mink are known to prey on waterfowl (Wilson 1954; Clark 1970; Sargeant et al. 1973; Chapman and Feldhamer 1982), ours seems to be the first reported case of surplus killing of waterfowl by Mink in the wild. In this case, only 3 of 51 carcasses (50 Eared Grebes, 1 American Coot) showed any signs of having been eaten. In British

Columbia, Eared Grebes nest in shallow alkaline lakes that lack fish. Mink, on the other hand, prefer lakes containing fish (Chapman and Feldhamer 1982). In surveys conducted on Eared Grebe colonies in British Columbia from 1985 to 1987, this is the only instance where surplus killing was observed. This suggests that surplus killing at Westwick Lake was an isolated event. The phenomenon of surplus killing, its impact on prey populations, and the factors affecting it deserve further investigation.

Acknowledgments

This research was supported by funds from World Wildlife Fund (Canada) and the Canadian Wildlife Service. We thank B. Saunders for identifying the predator as Mink, B. Nuttall for assistance in the field, and G. Martel for stimulating discussions. Sue Briggs helped in the field, and A. R. E. Sinclair, N. A. M. Verbeek, J. N. M. Smith, J. Eadie, P. Arcese, J.-P. L. Savard, W. Hochachka, D. Balph, M. L. Morton, A. J. Erskine and an anonymous reviewer provided useful comments on the manuscript.

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News and Comment

New Honorary Member and the 1987 Ottawa Field-Naturalists' Club Awards

At the 1988 spring Soirée a new Honorary Membership and the four Club annual awards were announced. In addition to reading the citations and presenting the certificates to those recipients able to attend, President Bill Gummer selected Dianna Thompson to receive the President's Prize. The Hanes Award winner received a limited edition print of a painting by artist Barry Flahey in addition to the certificate.

HONORARY MEMBER: Ibra L. Conners

Ibra Conners is one of the longest serving members of The Ottawa Field-Naturalists' Club. He maintains a membership that began over 50 years ago in 1933. He was already known as a meticulous student of mycology when he came to Ottawa to join the Central Experimental Farm research staff in 1929 as mycology herbarium curator and compiler of the annual Canadian Plant Disease Survey reports. He quickly established guidelines that significantly improved the quality of material added to the herbarium.

In 1950 Conners was instrumental in the establishment of a separate Mycological Section within the Division of Botany. Its herbarium was, after 1951, *the* national collection in scope as well as in name. From the strength of this collection he was able to complete his widely acknowledged book *An Annotated Index of Plant Diseases in Canada*, published in 1967.

Conners joined the Council of The Ottawa Field-Naturalists' Club in 1942, the year he became Treasurer. He immediately applied his meticulous attention to detail to the books of the Club and presented financial information in a much more lucid form than had been seen previously. Despite the difficulties of the World War II period Club membership increased, thanks largely to the efforts of Conners and other "activists". He remained as Treasurer until 1946 (producing the Club's first annual budget in the process) and presided over a slowly increasing base of financial security.

In 1947 he took on the primary responsibility for arranging Club sponsorship of the Audubon Screen Tour series in Ottawa. This involved prominent American naturalists (including the likes of George M. Sutton, O. S. Pettingill, Alexander Sprunt, etc.) providing a narration for a film or a slide show on a particular natural history topic. They were

immensely popular. Not only did it expose thousands of people to excellent natural history programs but it generated thousands of dollars for the Club. Due largely to Conner's organizational skill and hard work, over \$2200 was earned for the Club — doubling the existing reserves. At the end of five seasons that total was more than \$7000, thus providing the basis for the sound Members Equity that the Club now enjoys.

Ibra Conners remained active in The Ottawa Field-Naturalists' Club for many years before retiring to the United States. At 92 years of age he still corresponds with Club members in Ottawa and maintains an interest in Club affairs.

Few records of service can boast so long a commitment and this, coupled with his unique contributions to Canadian mycology, makes Ibra Conners a welcome and worthy addition to our list of distinguished Honorary Members.

MEMBER OF THE YEAR: Colin Gaskell

Colin Gaskell is a highly respected member of the Excursions and Lectures Committee. The Club has profited from this association in several ways. He is strong in committee work, active in the field and a mainstay at monthly meetings. Day trips and longer excursions in which he is involved are always thoroughly planned, and carried out with the expertise of an excellent leader. The highly successful field trip to Presqu'île Provincial Park in April 1987 is one example of his talent for leadership and ability to organize.

Colin is a knowledgeable birder and is generous in sharing this knowledge. He has provided valuable assistance to the Macoun Field Club in carrying out various field trips for these young people.

It is a pleasure for the Club to recognize Colin's active interest and valuable contributions in this important segment of our functions by naming him Member of the Year for 1987.

SERVICE AWARD: Gordon Pringle

The Birds Committee has looked upon Gordon Pringle as something of a pillar over the last five years or so. He has served in many capacities, including as secretary of the Birds Records Subcommittee and Chairman of the Bird Feeder Subcommittee. In these positions he has proven to be quietly and consistently effective, sorting out the

many small and large details that surround such functions. Whether coaxing assistance of others, arranging for distribution of seed to the various feeder operators, pursuing the best deals for seed supply or involving other groups in the bird feeder program, Gordon has gone about his task with great efficiency.

He played an important role in the team that produced the latest revision to both the annotated checklist and the field list for Ottawa District birds. Gordon has provided an enthusiastic and energetic second team on the annual Seedathon fundraising effort for several years now. He has thus contributed directly to the bird feeder and other bird related projects made possible from the proceeds of the Seedathon.

The assistance and support that he has provided to Birds Committee chairmen, has been largely unseen but greatly valued. He now serves as The Ottawa Field-Naturalists' Club Birds Committee chairman.

Gordon Pringle has been very successful in developing a co-operative spirit amongst others. His quiet, dependable, behind-the-scenes efforts have more than qualified him for the 1987 Service Award.

CONSERVATION AWARD: C. Graham MacNay

At one time when Eastern Bluebirds had almost vanished from this area, Graham MacNay began his project to attract them back by providing suitable houses at appropriate locations for them to nest in. It was a slow process at first but he finally had his Bluebird Trail — about 70 houses — in the Dunrobin area west of Ottawa. Many were occupied and produced young bluebirds.

One should remember that it isn't enough to simply build and locate the familiar houses we see along the roadside. A trail operator must visit his houses regularly to check conditions and to control the natural competitors for such nestlings; swallows, sparrows, wrens and mice. Vandalism and the acts of curious people also had a bad effect on the rate of successful breeding of bluebirds along this trail.

Careful records and observations on nesting pairs, numbers of eggs and broods and the total fledged young, form a valuable source of information on bluebird populations and habits along Graham MacNay's trail. As a spin-off, his success has encouraged others in Ontario and Quebec to establish similar bluebird trails. His labours have not only significantly improved the population figures for the Eastern Bluebird in the Ottawa District but have indirectly enhanced other populations as well.

We are pleased to recognize the valuable contribution to conservation in this area by Graham MacNay with the 1987 Conservation Award.

ANNE HANES NATURAL HISTORY AWARD:

J. W. (Jack) Holliday

As anybody will know who has read some of his many articles in *Trail & Landscape*, Jack Holliday is one of those rare individuals who has an overriding curiosity for even the most minute natural detail. His pen has captured the activities of such diverse creatures as toads, spiders, weasels, grosbeaks and butterflies. The painstaking observations are passed on in a folksy style that inspires others to follow in his footsteps.

A native of Ottawa, Jack has been studying nature in this region since his youth, and has left historical natural records in his writings that stand the test of time. Since his retirement, he has, if anything, stepped up his pace. He is actively corresponding with world-reknowned scientists to answer new enquiries arising from some of his more recent activities, such as raising Silk moths and tagging Monarch Butterflies.

Jack Holliday's field observations and activities, and his writings, make him an appropriate recipient of this award named after one of the Ottawa area's outstanding all-around field naturalists, Anne Hanes.

DANIEL F. BRUNTON

Chairman, Awards Committee,
and the members of The Ottawa
Field-Naturalists' Club Awards Committee

President's Prize — 1987

The President's Prize for 1987 was awarded to Dianna Thompson in recognition of her consistently strong efforts as a member of our Education and Publicity Committee. Her work culminated in the successful participation of the Club in the National Capital Commission's second "Fall Rhapsody", held from 19 September to 13 October 1987, in the Sussex Courts near the Ottawa Market.

The Ottawa Field-Naturalists' Club contribution was a workshop on bird feeders, as in 1986. Dianna worked to make this a real success and a valuable contact with the public. Its organization and operation included meeting National Capital Commission requirements, recruiting sixteen knowledgeable and willing Club members to man the exhibit, and taking part in a CBC radio interview.

For her role in bringing it to the level where it was reported in the Committee's annual report as "the highlight of the year", I was very pleased to present Dianna with the third of the modern President's

Prizes — which, at her request, was *Birds of Canada*.

W. K. GUMMER

President, The Ottawa Field-Naturalists' Club

Book Review Editor's Annual Report, Volume 101

Volume 101, from the book review perspective, has been our most hectic year to date. Coinciding with a busy period at home and office as well as numerous field trips, this has put me way behind at times. Apologies are due to any inconvenienced reviewers.

We are, as always, looking for more reviewers. I am also extending a plea to experienced reviewers who have not heard from me lately to re-establish contacts. Even my computer data file requires time that is often not available to keep track of the present 211 active reviewers.

Volume 101 saw 425 New Titles listed, at the high end of the last decade, but less than in volume 100. Other statistics virtually all broke records for *The Canadian Field-Naturalist*. The 200 books received (of these only 49 were requested for reviewers) was

almost double any previous year and three times as many as the previous year. Likewise for the 167 books sent to reviewers and the 144 reviews completed. The 85 reviews published was essentially the same as last year's record and will most likely be eclipsed in volume 102 as things catch up through the system.

As always, we appreciate any help from new or experienced reviewers in identifying books they are willing to review. Those we have received will be sent immediately while other appropriate titles can be requested from the publishers. New reviewers should include a list of areas of interest for my file.

WILSON EEDY

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Book Reviews

ZOOLOGY

Ecology and Natural History of Desert Lizards

By Eric R. Pianka. 1986. Princeton University Press, Princeton. xi + 208 pp., illus. Cloth U.S. \$45; paper U.S. \$19.95.

It seems that ecologists can be divided into two groups: those who feel that competition is an important force in organizing community structure and those who feel that the evidence is not very strong. One has only to examine the November 1983 issue of *American Naturalist* to appreciate the flavour of this intense, ongoing debate. Eric Pianka is clearly one who believes that competition is important. The word is first mentioned on page 4 of this book and appears repeatedly throughout. Pianka acknowledges that differences in the ecology of coexisting species might be due to non-competitive causes (page 35) and that there are non-competitive views of community structure (pages 76-77), but the subject is quickly dropped in both cases. This is therefore not a book that will teach its readers much about the state of modern community ecology. In any case, that sort of coverage is available elsewhere (e.g. J. Diamond and T. J. Case, *Editors*. 1986. *Community Ecology*. Harper and Row). However, it is a book from which one can learn a lot about lizard communities.

Pianka has been studying desert lizard communities for about 20 years, and his papers on the subject are well known. This book is essentially an overview of this major body of work. However, I am not at all sure whom the book is aimed at. On the one hand it has relatively few insights for the professional ecologist or herpetologist, but, on the other, it is hardly just a field guide to desert lizards. It probably will be of great interest to naturalists who want to learn about lizard ecology in a relatively simple theoretical framework. Pianka writes in an easy, enthusiastic style with occasional personal asides (his favourite lizard is the pygmy monitor). Reading his book aroused in me a keen desire to go out into the field to watch animals and measure things.

This book is very short and divided into 12 chapters. The early chapters include descriptions of deserts and their lizard faunas, and discussion of

various aspects of lizard ecology. I especially liked the chapter on natural history miscellanea (Chapter 6). Chapter 7 on the analysis of community structure is the first real discussion of any general ecological literature, but on a fairly simple level. Chapters 8-11 concern various kinds of analyses of community structure, generally involving comparisons of desert saurofaunas of North America, Australia, and Africa. These chapters contain original analyses of old and new data. Most interesting to me was the comparison of Australian desert lizard faunas examined 12 years apart, revealing numerous substantial changes (Chapter 10). The book is laced with figures and tables, making it very short on text. Seven appendices also are included, each summarizing relevant data from Pianka's studies. Twenty-nine attractive colour photos adorn the book's midsection (interestingly, there are no shots of North American lizards or habitats). A reasonably healthy reference list rounds out the book.

Although this book is well worth reading, it could have been better organized. For example, the appendices are an extremely useful source of data for others to compare with their own studies. However, the vast open spaces around them should have been used to create more informative captions. For instance, Appendix A lists species diversity values for various sites, but one has to search through the text to discover that it is Simpson's index of diversity that was used. A more nagging point is that there are occasional slight discrepancies between numbers presented in tables in the text and in the appendices (e.g. compare species totals in Table 1.1 and Appendix A). The tables and figures presented in the body of the text are generally informative, but a few seem to say little, if anything (e.g. Table 11.3). Some could use more informative captions (e.g. units of measurement in Figure 5.3). References to sources of material would have been useful in captions of both figures and tables.

Although Pianka summarizes an impressive volume of data in this book, he reaches few real conclusions. We learn that lizards in a community

separate themselves ecologically, that species diversity varies among communities, and that the nature of community organization varies among continents, but there is little to take away beyond the observation that the world is a variable place (which admittedly may be ecological reality). Some of Pianka's speculation strikes me as being somewhat fanciful (e.g. a "periodic table" of lizard niches, page 47). The value of his analysis of computer-generated "pseudo-communities" is also debatable, especially given its reliance on rather

tenuous assumptions. Overall, however, the book is well-written, interesting, and nicely produced (I found only one spelling error). Given its small size, its biggest weakness may be its high price; for that reason alone it may fail to find a deserved place on the bookshelves of many naturalists.

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Inventory and Monitoring Of Wildlife Habitat

Edited by Allen Y. Cooperrider, Raymond J. Boyd, and Hanson R. Stuart. 1986. U.S. Department of the Interior, Bureau of Land Management. Service Center, Denver. xviii + 858 pp., illus. Cloth U.S. \$38.00.

The inventory and monitoring of wildlife habitat has emerged as an important management tool in the last two decades. This book is testament to the fact that biologists, managers, administrators, and the general public now realize that habitat is the key; without habitat, there can be no wildlife. Our knowledge of the interrelationships of habitat and wildlife has, and continues, to rapidly evolve. And although the science is, as yet, rudimentary and the perfection of many management techniques continue to elude biologists, this book demonstrates that the wildlife resource is a measurable entity which can be legitimately addressed within the context of integrated resource management.

The book is organized to assist biologists and resource managers in their efforts to plan and implement wildlife inventory and monitoring programs. The book is based on the assumption that certain habitat attributes can be used to predict the distribution and abundance of wildlife species. In this context, habitat inventory is described as techniques employed to measure habitat variables in order to infer the distribution and abundance of wildlife, while habitat monitoring is issue-oriented and consists of repeatedly measuring habitat and population variables to infer changes in the capability of the land to support wildlife.

Although the book was primarily designed for use by staff of the U.S. Bureau of Land Management, it is of interest to any biologist and manager engaged in inventory and monitoring work. It contains six sections with the chapters in each section focused around a central theme.

Section I contains four chapters which focus on the inventory and monitoring process, data types, literature review techniques, and habitat mapping principles. The chapters are designed to assist biologists in their preparation of studies of habitats in which they have little or no experience.

Section II has eight chapters which contain guidelines and monitoring techniques for specific habitats, including forests, rangelands, deserts, tundra, riparian habitats, marshes, streams, and lakes. The authors of each chapter endeavour to provide information on classification systems, important species groups and habitat features, major impacts, and problems associated with inventorying and monitoring specific habitats.

In an effort to discuss the diverse array of wildlife species, Section III is organized into 12 chapters of animal groups. It is important to note that the species discussions are not organized according to their taxonomy, but according to techniques which can be employed to measure habitat and wildlife. The habitat components and current techniques for population inventories and monitoring are briefly described. Those who want additional information are referred to the references cited in the text. The chapters are focused on: fish, amphibians and reptiles, songbirds, raptors, marsh and shorebirds, waterfowl, colonial waterbirds, upland game birds, rodents and insectivores, lagomorphs, carnivores, bats, and ungulates.

Section IV outlines techniques employed to measure habitat variables. But more important, the chapters are designed in a manner that allows the reader to understand the relationships between wildlife and their habitat. The chapters focus on soils, terrestrial physical features, aquatic physical features, hydrologic properties, water quality, vegetation, and macroinvertebrates.

Section V addresses specific monitoring techniques related to food habits, climatological studies, studies of movement (eg., radiotelemetry), and habitat use. Section VI describes techniques which can be employed to facilitate appropriate data management, statistical analyses, habitat evaluation systems, evaluation and interpretation, economic analyses, written communications, and verbal presentations.

The book is well organized and easy to read. It is well illustrated with the use of graphs, example work sheets, photographs, drawings, maps,

Landsat scenes, and cartoons. In addition, a glossary of terms and an index are included at the end of the book. Experienced habitat management biologists may find some sections rudimentary, but on the whole, it is an excellent publication, and I recommend it to students, academics, biologists, and managers.

PAUL A. GRAY

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Fish

By Kenneth Doan and Richard Osen. 1986. Canadian Album Series, Nature Stories for Children, Hyperion Press Limited, Winnipeg, Manitoba. 40 pp., illus. \$4.95.

This book is one of a series. Other titles include *Small Mammals*, *Large Mammals* (two volumes), *Insects*, *Birds* (two volumes), *Wildflowers*, *Time and Life* (Fossils), *Trees*, *Butterflies and Moths*, and others are planned on *Owls*, *Invertebrates*, *Dinosaurs*, and *Endangered Species*.

Fish has a standard format for 19 species of freshwater fishes. Each species occupies two pages, one for text and one for an illustration. The text comprises a story about the fish and a factual description. The illustration shows each fish in a habitat which relates to the story. The stories can be entirely from the fish's point of view or involve human interactions with the fish. All the stories contain information on fish biology, presented, I assume, in a more digestible fashion than the factual section. This latter gives the family name, length, weight, age, distribution, habitat, economic role, remarks, and colour.

My own opinions on this book are diverse. The title is a misnomer since only freshwater fish are treated and the rich fauna of the longest coastline of any country in the world is omitted. Perhaps a *Marine Fish* book is in the offing. Any book on Canadian fish omitting cod, on which the country was practically founded, leaves a lot to be desired.

The choice of species must be a personal one of the author as only a fraction can be dealt with. Ontario readers will miss the Pumpkinseed of small child angling and cottage fame and few would be familiar with sturgeon, burbot, and Arctic Grayling. Interesting and unusual species make for a good read but a better selection of familiar species makes for a sense of immediacy and relevance to the child's experience.

I didn't like the drawings (but see below). They are of poor quality compared to others I have seen in the same series. They are impressionistic sketches and are not accurate in details. The Carp, for example, has inaccurate scale and fin ray counts and too few barbels.

The book contains no guide for the benighted parent or other buyers trying to tailor their purchase to the child. The story parts are accessible to a younger age group than the factual descriptions. This difference in content may have been an attempt to cover a range of ages. The description contains interesting information but there are a number of other books on the market dealing with a wider range of fishes. I wouldn't recommend it as a source book for class projects but it would appeal to children with an unfocused curiosity about fishes. Children are prone to re-reading endlessly a familiar book and this is one they could grow with and absorb more as their interests and abilities change.

My co-reviewers range in age from 6 to 10. The youngest had the stories read to them by a parent, the oldest read for themselves.

The youngest found the stories too technical, with too many scientific words but nonetheless enjoyed them and felt they had learned a lot about fish. Older children were able to read and enjoy the stories, tripping over the occasional technical word, such as mollusc, where an English alternative is more familiar (clam, snail). Some of the story lines were a little confusing, such as Perch spawning on a barbed wire fence which caused comment about this fish wandering around fields, and the statement that most of the eggs wouldn't hatch without any explanation. The layout, with text on one page and a drawing on the facing page, was praised. All the children liked the drawings

although there was a minor plea for colour. One child was offended by the inaccuracies in the drawings. The general opinion was that the book was interesting and informative. One child recommended it for class projects in contrast to me. The factual descriptions contained too many "big" words for 9-10 year olds and would only succeed with an older age group.

The series is an excellent idea and its younger audience has received it with approbation.

BRIAN W. COAD, with NICHOLAS COAD,
JAKUB HOLY, IAN LLOYD, JAMES LLOYD,
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Insects, Nature Stories for Children

By Barbara Batulla. 1985. Canadian Album Series,
Hyperion Press, Winnipeg, Manitoba. 39 pp., illus.
\$.495.

This is one of a series of natural history coloring books for children. It consists of 19 full page drawings of selected common insects. Each illustration is accompanied on the facing page by a brief narrative in one column and a similarly brief but more technical account in the other column. The narrative usually is in the form of a story involving children encountering the insects and discovering facts about their biology. The technical account presents the order and family names of the insects, information about their distribution, food, reproduction, biology, and ecology. Finally, there are details about the natural coloration of the insects. This combination of narrative and technical account makes the book suitable for children from 8 to 12 years old, although younger children may certainly enjoy coloring the pictures.

The drawings are large and depict the insects in natural settings engaged in typical behavior. The written accounts should prove entertaining as well as informative for the young audience for which they are intended. Unfortunately, there are some factual errors that detract from the overall quality of the book. The author incorrectly claims that

water scorpions possess poison claws on their front legs. Under dog-day cicada the sound producing mechanism and hearing organ are improperly described as located on the last abdominal segment and the sound as being produced by air forced past a membrane. In fact, both the tymbals and tympana are located on the first abdominal segment and sound is produced by contractions of muscles attached to tymbals. The technical account also errs by referring to cicadas as flies. An error also occurs in the drawing of the spittle bug nymph which is shown as head up rather than head down on the plant stem. In the correct head down orientation the spittle froth flows due to gravity from the anal end downward to cover the entire insect. In the head up position the froth would not cover the nymph.

I doubt these errors will detract from the enjoyment that most children or their parents will get from reading and coloring this book, but it is unfortunate the mistakes were not eliminated prior to publication.

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The Greenland Caribou: Zoogeography, Taxonomy, and Population Dynamics

By Morton Meldgaard. 1986. Meddelelser om Grønland, Bioscience 20. (The Commission for Scientific Research in Greenland), Copenhagen. 88 pp., illus. Dkr 130 + postage.

The author presents a comprehensive analysis of the history of caribou in Greenland. The information available from geological and archeological studies has been integrated with the

historical literature, statistical data from the fur trade, and game branch hunting records. Meldgaard's personal involvement in Greenland field studies commenced with his participation in an interdisciplinary study of archeological sites in 1976.

In order to trace the history of caribou occupation the author divided the unglaciated coastline of

Greenland into twenty "caribou regions" and then related his source information to each region. That treatment provided evidence of interrupted occupations of some regions, extinctions and immigrations in others. Meldgaard constructed the post-glacial caribou zoogeography of Greenland based upon that descriptive material.

The major conclusions are that sometime prior to 6000 B.C., a small caribou (*pearyi* — sized) immigrated into north Greenland from Ellesmere Island. (The date is based upon a recent C-14 determination on an antler fragment from Peary Land). He questions the existence of the theoretical peri-glacial refugium in the Queen Elizabeth Islands and north Greenland. He joins other authors in concluding that the climate of the unglaciated areas during the Wisconsin-Weischel glaciation would have been too severe to permit the continuous survival of most mammals. He suggests the first caribou came from Beringia (I am not persuaded to abandon the northern refuge theory yet. My study of Alaskan Wisconsin-age caribou bones suggested a population of large caribou.) This first small caribou spread down the west coast as far as Cape Farvel and down the east coast to Scoresby Sound.

Sometime prior to 2000 B.C. (during the Hypsithermal period) a larger caribou (*groenlandicus*-sized) immigrated from Baffin Island across Nares Strait via Devon and southern Ellesmere Island to northwestern Greenland (via Melville Bay). Meldgaard does not give much credence to the possibility of immigration directly across Baffin Bay ("the sweepstake route"). These larger caribou displaced the smaller race down the west coast of Greenland as far as the Sukkertoppen Iskappe. They finally overcame that barrier sometime between 1500 BC and 1000 AD and reached southwestern Greenland prior to the Viking period. Meanwhile, a dwarfish caribou inhabited the east coast in the isolated Ammassalik region between 300 AD and 1200 AD. Meldgaard favors the theory that the colonization of this area was undertaken by the small caribou of

southwestern Greenland. For the past 1000 years the caribou range of southwestern Greenland has shrunk by about 50 percent.

Meldgaard's extensive data permitted several important conclusions to be drawn regarding caribou population dynamics. He noted generally synchronized population fluctuations in Greenland with a periodicity that varied between 65 and 115 years. During these cycles the population changed by as much as 90 percent and in some cases resulted in extinctions. His data also confirmed certain generalizations about caribou distribution during population fluctuations that have been drawn by North American caribou biologists. During population peaks caribou undertake pronounced annual migrations and expand their ranges to include marginal winter ranges. During population declines the distributional area shrinks and the caribou remain relatively static near the calving grounds. He also noted that during peak populations caribou increase in size and decrease in size during population lows.

Based upon an analysis of 100 years of weather data Meldgaard concluded that short-term climate fluctuations were the main cause of population fluctuations. During periods of oceanic climate characterized by warmer and wetter winters and cooler summers, the caribou population declined. With a return of more continental climate characterized by colder and dryer winters and warmer summers the caribou increased. Overhunting may have been responsible for the extermination of some isolated herds.

This is the definitive study on the zoogeography of Greenland caribou with implications for caribou distribution on a wider scale. I was pleased to note that the monograph was dedicated to Christian Vibe who has spent a lifetime researching the Greenland fauna.

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Auks: An Ornithologist's Guide

By Ron Freethy. 1987. Facts on File Publications, New York. 208 pp., illus. + plates. U.S. \$24.95.

Auks is a well-written, enjoyable book summarizing the biology of this interesting family. Written for popular, rather than professional consumption, it does not give large doses of detail.

Rather, it concentrates on essential points, as they are known, and provides a concise account that should satisfy most avid bird enthusiasts. There is a heavy bias towards those species which occur in Europe. I suspect that this is not from any preference of the author, but more a reflection of

the large imbalance of knowledge and research effort between Europe and North America. In fact, the author can be commended for assembling the Pacific data and, by using his extensive knowledge, filling in the gaps with believable background material. Even within North America there is an imbalance, with the Atlantic species getting more attention than those from the west. The author has smoothed the inconsistencies out and has produced as balanced a book as possible.

This book is too advanced for the novice and not sophisticated enough for the professional specialist in auks. It might be enjoyed by other professionals, however it is likely to be enjoyed best by the growing population of serious birders. With this in mind, there are several passages that are too simplistic even for amateurs. The explanations, for example, on classification and ringing (or banding) are very basic, and are inconsistent with the tone of the book in general.

After introductory chapters on classification, general biology, and ecology of the alcids, the first species account is a surprisingly detailed history of the Great Auk. It is sad that such a fascinating bird is no longer with us. Or perhaps it is, as the author raises an imperceptibly faint hope that Great Auks are still living somewhere near Scotland. In the next chapter, the Little Auk or Dovekie gets so much attention, I wonder if it is not Freethy's favorite. Habitats, breeding sites, movement, breeding behaviour, food, and feeding are all explored in some detail. Although not primarily concerned with identification the author does not ignore the subject. A brief description is included in each species account. His description of Dovekie spends a disproportionate time on the underwing colour. This he states thus "regardless of origin age or seasonal plumage, all (museum skins) had dark brown underwings". This agrees with my experience and some other published information, however, there was a lively debate on this issue several years ago in *British Birds*. The ends of the underwing covers can form a narrow white bar but some authors say the entire underwing can be pale. Indeed the colour plate in this book shows a bird with upraised wings and the undersides are almost

entirely greyish-white! This does not appear to be a trick of the light so the colour of Dovekie underwings remains perplexing.

Similar chapters follow on the Razorbills, Murres, Guillemots, Murrelets, Auklets, and Puffins. Freethy has put Rhinoceros Auklet in with Puffins, which he feels is justified but does not explain. In all, 22 alcids are covered and a 23rd possibility (Snow's Guillemot) is mentioned. Subspecies are discussed as far as the author feels is appropriate. Again to show how disproportionate the data are, there are 20 subspecies for the Atlantic auks and only four described in the Pacific; the accepted original home of alcids (and this includes the disputed Snow's Guillemot).

Within the text are some particularly interesting sections. I was fascinated by the examples of chickless Gannet parents "adopting" (stealing?) murre chicks. The results are sadly disastrous for the chick. The possibility of Vitamin D production from preening oil and sunlight is another intriguing possibility worthy of more research. I would have liked to see a discussion of the comparative biology of Black and Pigeon guillemots where their range overlaps, but this was not included.

This book is illustrated by respectable line drawings and a small number of excellent photographs. The range maps are clear and consistent with accepted, published information. There is a substantial bibliography.

The last, short chapter is titled "Auks in the Modern World" and is a sad note to close on. Fishing, pollution and other human impacts have generally been negative. Auks are so appealing that we can hope there will always be some one to fight for their cause.

Auks, then, is a good book and I recommend it as an addition to your collection or as a gift. As the author has written other books, we can hope he will continue to supply us with good quality texts for a long time to come.

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Measuring Behaviour — An Introductory Guide

By Paul Martin and Patrick Bateson. 1986. Cambridge University Press, Cambridge, New York. 200 pp., illus. Cloth U.S. \$27.95; paper U.S. \$7.95.

Field naturalists often have unique opportunities to observe animal behaviour but lack the

know-how to record behaviour in a quantitative, scientifically acceptable manner. This short, simple, clearly-written book is an excellent guide to those who are beginning research in behavioural biology.

The book deals mainly with methods based on direct observation of behaviour (as opposed to automatic recording devices) and covers such topics as defining behavioural categories, time sampling procedures, the design of check sheets, and ways of determining inter- and intra-observer reliability of observations. No coverage is given to field equipment (spotting telescopes, directional microphones, time-lapse film techniques, etc.), but computer-compatible event recorders are discussed in some detail. An excellent feature is the 30-page bibliography with helpful annotations to guide the reader to appropriate references for further study.

The book was planned mainly for students with no previous experience of research. Consequently the approach is very elementary and may turn off some readers. For example the text explains such terms as "random sample", "control group", "null hypothesis", and "circadian rhythm". The usual cautions are given about anthropomorphism and about inferring causation from correlation. The elementary approach is particularly pronounced in the section on field work. For example, field workers are warned that "bad weather may make observation impossible" and that "field work . . . requires flexibility and a readiness to change plans when a course of action is frustrated by unexpected difficulties".

Nonetheless, parts of the book can be read with profit by experienced workers. I particularly liked the balanced and up-to-date treatment of one-zero sampling, the distinction between literal and constructive replication, and the detailed treatment of methods for assessing the reliability of observational measures.

In the chapters on social behaviour and data analysis, the elementary approach that was used successfully in the earlier chapters tends to degenerate into uneven coverage of selected topics. The chapter on social behaviour deals extensively with dominance hierarchies in established groups, but gives little guidance on studying aggressive behaviour, mating, or parent-offspring behaviour. I would like to have seen an introduction to recording social interchanges and to the use of transition frequency diagrams and other methods for presenting and analyzing such data. Similarly, one third of the chapter on data analysis is devoted to the uses and abuses of correlations. The points made are valid and useful, but why the detailed treatment of this one topic? I would rather have seen guidelines on when various multivariate techniques are useful, cautions on the treatment of counting versus measurement data, and advice on when statistical expertise should be sought.

In short, I would recommend the first hundred pages of this book, together with the final chapter, as an excellent guide to quantitative observational study of behaviour. For information on field equipment, this book does not replace the eclectic *Handbook of Ethological Methods* by Lehner (1979); and even for elementary aspects of data analysis, the reader will still have to use other standard books on biometrics.

Literature Cited

Lehner, P. N. 1979. *Handbook of Ethological Methods*. Garland STPM, New York.

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Helping and Communal Breeding in Birds: Ecology and Evolution

By Jerram L. Brown. 1987. Princeton University Press, Princeton. xvii + 354 pp., illus. cloth U.S. \$45; paper U.S. \$16.50.

In more than 200 species of birds, individuals regularly assist in the raising of conspecifics not their own. For the many ornithologists and behavioural ecologists fascinated with the issues raised by this activity, Brown presents a detailed and critical synthesis. The author is well known for his work on this topic, his more general contributions to the theory of avian social behaviour, and his text on the evolution of animal behaviour. His presentation begins with an

introduction to the natural history of the phenomenon, the history of its study, and the importance of the theory of inclusive fitness, reproductive success achieved both directly and indirectly via kin. Brown then focuses attention on the three central variables of delayed breeding, reduced dispersal, and helping behaviour *per se*. Helping can arise both from assistance in a nuclear family and from the sharing of nests and mates. The inheritance of a breeding territory by helpers can be viewed as a form of parental facilitation enhancing their reproductive potential. Cooperation, or mutualism, involves costs and benefits

associated with group size, mating pattern, and parental certainty. The many aspects of cooperation are examined in detail and illustrated with specific examples, such as the importance of food storage in acorn woodpeckers for the maintenance of permanent territories.

Data on the ethology and population genetics of helping species show that helpers do actually enhance the raising of offspring and that they are related to their beneficiaries. The criticality of kinship is emphasized by Brown since it is central to the controversy which has engaged him with other researchers, most notably Glen Woolfenden, who have downplayed kin selection as a driving force for helping in preference for augmentation of the direct fitness of the helper. It is clear in this section of the book that Brown has been distressed at what he regards as inadequacies in others in distinguishing central variables and alternative hypotheses, and evaluating data and using theory, including his own. In the denouement following this controversy, Brown concludes with an examination of some remaining matters and a synthesis. Relations between parents and offspring indicate how variance in the expected fitness of young can lead to helping while destructive social behaviour can include nest robbery and infanticide. The material of each chapter is usefully summarized in conclusions, and an appendix on the evolution of helping behaviour, an annotated

glossary, and full references and indices are included.

Throughout the work Brown is at pains to explicate alternative hypotheses and discriminating tests, as for instance on the causes of delayed breeding. There is a good interplay between data and models (including games theory for different behavioural strategies) on successive issues, and attention to areas of ignorance and to feasible but missing field experiments (as on the role of dominance). Brown achieves his central aim of supporting his interpretation of the available observations as implying the important role of kin selection. The organization of the book could have been tightened to facilitate a smoother transition through the different facets of helping. As an example, the relation of direct and group territoriality, considered in Chapter 17, could easily have been included with other general features of natural history covered in Chapter 3. For their part, ethologists could hope for more information on the social dynamics of helping. Notwithstanding these blemishes, this is a broad and careful exposition of the ecology, genetics, and evolutionary biology of helping behaviour.

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Foraging Theory

By David T. Stephens and John R. Krebs. 1986. Princeton University Press, Princeton. xiv + 247 pp., illus. Cloth U.S. \$40.00; paper U.S. \$14.50.

Over recent years attempts to find adaptive explanations for the richness of feeding, mating, and parental patterns observed across many species have dominated the field of behavioural biology. This adaptationism views natural selection as an optimizing process over evolutionary time. The most successful area in this adaptationism has been optimal foraging theory, and the present book represents a synthesis and defense of this theory. The authors begin by detailing the formal elements of foraging models: behavioural decisions, currencies to be maximized, and constraints from various sources. Consideration of the maximization of the average net rate of intake includes reviews of prey and patch models of searching, encountering, and handling, with the attendant problem of travel costs, prey recogni-

tion, and the effects of nutrients and toxins. Subsequent chapters treat topics such as sampling from changing environments, trade-offs between feeding and survival, variable food supplies, dynamic foraging decisions (an extremely complex issue), and rules of thumb which proximately determine feeding. The concluding examination of the testing of foraging models and the underlying soundness of optimization theory in biology includes valuable discussion of methodological matters, a review of published tests, and responses to critics, especially S. J. Gould and R. Lewontin. Each chapter ends with a summary, and specific topics are highlighted in boxes. Aside from the use of "behaviors", the book is well composed and illustrated.

A wide diversity of foraging data and theory is drawn together in this lucid and energetic presentation. Particularly exciting is the interdisciplinary use of ethology, ecology, economics, and

quantitative tools including statistics, signal detection theory, and dynamic and linear programming. Insights are also provided on the comparison of models, alternative interpretations, problems such as the limitations of linear operator models, and the unity that can arise from apparently disparate results (e.g. risk aversion and risk proneness). Amid their vigorous defense of adaptationism, the authors acknowledge topics for which further research is needed, as in the cases of partial preferences and customizing general models to specific contexts. On the other hand,

workers interested in the metabolic and behavioural aspects of feeding, such as individual differences, will feel that these aspects have been given short shrift in being treated merely as constraints to functional issues. Nevertheless, as a work focused on the state of foraging theory, this volume provides an excellent exposition.

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Ecology and Evolution of Darwin's Finches

By Peter R. Grant. 1986. Princeton University Press, Princeton, New Jersey. xiv + 458 pp., illus. Cloth U.S. \$55; paper U.S. \$22.50.

This is an important book, well-written and attractively presented. It will presumably be bought by the libraries of most academic institutions with biological pretensions, should they still have funds for acquisitions. It should be bought by many individual biologists, as an intellectual stimulant and as a model of lucidity. But how many biologists buy, read, and take pleasure in owning books on topics not related to their current concerns?

The peculiar merit of Professor Grant's book is that it performs two overlapping but substantially different tasks, and performs both of them unusually well. The larger part of the book reports the results of intensive and lengthy field studies on the distribution and behaviour of the group of 14 species of passerines forming the subfamily Geospizinae, confined to the Galapagos and Cocos Island, which, from a common ancestry, have come to exhibit a remarkable diversity of form and functions. The field studies were supplemented and guided by detailed work on beak shapes and sizes, and on the underlying musculature and mechanisms. Having set the scene geographically, taxonomically and morphologically, Professor Grant centres the work, first, on study of the diets of the different species and the importance of what food is available in imposing limits on finch populations and, second, on the mechanisms of species recognition and mate choice. These have been popular academic topics in the last decade or so.

The discussion then proceeds to some less fashionable but more fundamental subjects, including evolution and speciation, competition, adaptation, and the reconstruction of phylogeny,

most of which received more attention (from a much smaller corps of biologists than now exists) in the 19th and first half of the 20th century than they have in recent years. This re-examination and illumination of major themes that had been set aside has been made possible by intensive work by Grant and his associates since 1971. They have greatly enriched one of the classical examples in "biological history".

For someone who is not a specialist in this field a second theme emerges, not wholly explicitly, which is a contribution to the "history of biology". The Geospizinae have been known as Darwin's Finches for over 50 years, in recognition of his part in bringing them scientific fame, although he was not the first to see or describe them. But Darwin was so puzzled by the Galapagos finches that he made no reference to them in the *Origin of Species*. Part of his puzzlement was due to the genuine complexity of the situation, part to the fact that he spent only five weeks on the islands and collected specimens of only 9 of the 14 species. Most endearingly to those of us who have also made elementary blunders in our own research (and who has not?), he made things harder for himself by failing to label separately the specimens he collected on different islands. So he had the good sense to "say nowt about it" except in his *Journal of Researches*, that wonderful quarry of observations and ideas.

The surge of recent interest in the Geospizinae began in 1931, when the American H. S. Swarth, basing his work on a large collection of material made on behalf of the California Academy of Sciences in 1905-1906, produced the first modern taxonomic treatment. In 1936, in Germany, Erwin Stresemann, also working with museum specimens and with no first-hand knowledge of the islands and

the living birds, developed ideas on the diversification of the finches. Then David Lack, from England, who spent more than three months on the islands in 1939, and published several papers on the Geospizinae during the Second World War, published the monograph *Darwin's Finches* in 1947, which built on the ideas of Swarth and Stresemann and enriched them with his own first-hand observations. That monograph became a classic, and was reissued very recently, with an introduction by Peter Boag.

As Professor Grant makes very clear, the major advances he and fellow workers made on the studies by earlier generations of ornithologists were possible because of improvements in logistics and in funding, which have made working conditions on the "nearly always unpleasant" (Lack's phrase)

Galapagos Islands and in other harsh places much less unpleasant. The islands are now part of the national parks system of Ecuador and the Charles Darwin Research Station was set up on Isla Santa Cruz in 1966. Scientists can now stay for long periods, work in teams, and make repeated visits. No wonder that they can obtain more and more reliable results than their predecessors. But it takes a first-rate scientist to tell as absorbing and convincing a tale as does Professor Grant, aided by publishers who have produced a book that is very good to look at. A warm note of thanks to everyone involved.

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A Systematic Study of the Nearctic Larvae of the *Hydropsyche morosa* Group (Trichoptera: Hydropsychidae)

By Patricia W. Schefter and Glenn B. Wiggins. 1986. Life Sciences Miscellaneous Publications, Royal Ontario Museum, Toronto, Ontario. 94 pp., illus. \$14.25.

For any biologist faced with the task of sorting benthic samples and identifying aquatic insect larvae, the genus *Hydropsyche* represents a considerable challenge. The head capsules of the relatively large larvae often are plainly marked with striking color patterns. Because of this there has been a strong temptation to utilize the markings for species identifications, and several authors have published keys to species that are based largely on head capsule color pattern. None of these efforts have been entirely satisfactory because there is a high degree of generally unrecognized intraspecific geographic variability. The need for more reliable characters that are less variable over the entire range of each species has been apparent for some time. This volume, although restricted to species of the *morosa* group, presents a careful analysis of characters that appear to meet this need.

The result of several years of study, this book is important for two reasons. First it will introduce caddisfly workers and other systematists to a new suite of setal characters that will prove to be immensely valuable for the identification of caddisfly larvae and that also will prove to be indispensable for phylogenetic analysis. Although Wiggins previously has discussed the potential for setal characters for systematic study of Trichoptera (Williams and Wiggins 1981), the present

publication is likely to have greater significance because it clearly demonstrates the practical utility of setal characters. There is a small school of students of Trichoptera, including a few young newcomers, who consistently ignore the immature stages in phylogenetic analysis. The usual (invalid) argument for slighting larvae has been the paucity of characters compared with the adults. The large number of characters demonstrated in this work by Schefter and Wiggins, and in work by Wiggins' other students should go a long way in helping to dispel such attitudes.

Second, it will be the standard reference of *morosa* group larvae for many years to come. The nature of the characters and their newness has led to the keys being rather long. But with careful attention to the clear exposition of the setal types at the beginning and reference to the numerous illustrations throughout, biologists will soon discover that they are able to consistently and correctly identify larvae that they previously had lumped under *Hydropsyche* spp. The authors examined a large number of specimens from all parts of the ranges of most species ensuring that virtually all significant geographical variation has been accounted for in constructing the keys and writing the diagnoses. This thoroughness and the use of morphological characters rather than color patterns have resulted in a highly reliable and practical key.

The book is successful both as an identification manual and as a vehicle demonstrating the

importance of setal characters to a wider audience. I recommend it to caddisfly workers, systematists, aquatic biologists, students, and anyone else who may have occasion to identify larvae of species of the *Hydropsyche morosa* group.

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Williams, N. E., and G. B. Wiggins. 1981. A proposed setal nomenclature and homology for larval Trichop-

tera. Pages 421–429 in *Proceedings of the Third International Symposium on Trichoptera*. Edited by G. P. Moretti.

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The Sparrowhawk

By Ian Newton. 1986 Poyser (Buteo Books, Vermillion, South Dakota). 396 pp., illus. U.S. \$35.00.

This book is about *Accipiter nisus*, a widely-distributed Eurasian raptor that in size is between our own Sharp-shinned Hawk (*A. striatus*), and Cooper's Hawk (*A. cooperii*). In this, his third book, Ian Newton has gathered together a considerable body of information. It comes largely from his own 14-year study in southern Scotland, but he benefits also from several very good previous studies.

The book has much to recommend it, both in the thoroughness of Newton's investigations, and in the clear style of presentation. The interpretation of his data is always on the cautious side — sometimes he strikes the reader as overly conservative in accepting a result. He takes pains to think of all the possible alternate ways in which the findings could be viewed. On the other hand, Newton is fond of letting his mind wander over the various interpretations and implications. This kind of style makes for satisfying reading — the critical reader has little to complain about in the presentation of data, while there is much food for thought in the musings and speculations.

Words are carefully used in the book. Newton refers to the birds in each study area as a population, for example, but cautions that in reality the population should be regarded as spread more or less continuously throughout Britain.

The book touches on many topics of interest to ornithologists and ecologists in general — using the specific example of the Sparrowhawk, it addresses such questions as size dimorphism, nest spacing, hunting success, diet specialization, and many more. Newton seems to have decided early on to measure as many parameters as possible — the result after 14 years is that even incidental questions can be looked at from a factual basis. For example, in the course of banding birds, records were kept of the exact order of plumage

loss during moult, and of the changes in eye colour individual birds undergo during their lives. While walking through each wood, he paced out the distances from trunk to trunk — then by noting the areas where nesting occurred, he was able to predict accurately the suitability of any wood for Sparrowhawk nests. The suitability of various tree species for nest location was looked at in relation to the growth form and foliage of the different trees. Similarly, the effectiveness of different twig types for nest construction was recorded: larch was the very best building material as its twigs are easily broken and lock together well because of the nodules. Newton analyzed in some detail the specific factors involved in nest spacing in different areas, incorporating such things as land productivity, elevation, landscape, and prey density. This type of information is of potential value as an adjunct to such projects as breeding bird atlases and population estimates.

One of the more gratifying aspects of the study overall is the judicious and thoughtful balance that was struck between what one might call invasive and non-invasive methods. Many days were spent tramping the forests of the study areas, finding all the nests, and making what fleeting observations are possible with this surprise attack kind of hunter. Every moulted feather found near nests was picked up and carefully studied. Newton developed a method for the individual recognition of female birds using the unique and characteristic pattern of the flight feathers, and was able to check the method's reliability with known ringed birds. It has been used successfully with Goshawks, and he suggests that it would work with other raptors with patterned flight feathers. More invasive methods such as banding, recaptures, and radio tracking are used cautiously, and with due concern for their effects on the birds. Also included are some data from previous workers employing older methods such as stomach content analysis, egg collections,

and "removal" experiments, as well as information obtained through falconers and falconry.

There are a number of recurring themes throughout the book, reflecting in part Newton's own interests, but also critical and all-pervading parameters in the lives of Sparrowhawks. The question of food supply is one of these: its relation to hunting ability, resistance to other pressures in the lives of the birds, dispersal, laying dates, territory size, and migration. Another is the size dimorphism between male and female Sparrowhawks, and how this affects almost every aspect of their lives: the roles of the two sexes in courtship, incubation, prey selection, and territory. Newton's interpretation of this situation is too involved to summarize here, but it is quite convincing.

Perhaps because Newton chose for his research "... those aspects which have caught [his] own interest", the book is lively and contains all sorts of insights into the numberless little questions to which there are usually no good answers available. How thoroughly does a hawk cover its territory? The Sparrowhawks apparently search every patch of cover over their range with striking thoroughness, checking "every hedge, every isolated bush, every stack or brushpile, every ditch and every other irregularity of the terrain which may have harbored prey." What is the percent of hunting success? It is somewhat surprising that although small birds are abundant for much of the year. Sparrowhawks often have difficulty in feeding themselves. Newton discusses the defenses

employed by the small birds, and how these often prove a match for the stealth and manoeuvrability of the hawk. In this and other instances, the author benefits from his previous studies on finches — he has viewed things at different times from the perspective of both the prey and the predator. He remarks on the great need for concentration by the hawk at the time of attack. This helped me to appreciate the benefit to small birds in pestering predators that they could never hope to actually injure, something I had always wondered about.

Throughout the book, one sees frequently behaviour patterns that appear to be not only adaptive, but essential for the survival of the species. For example, Newton cites the amazing endurance of the incubating hen during rain storms or extremes of heat. He shows how in this species, fidelity to territory from year to year is more important than fidelity to mate.

The book contains a selection of good photographs, and the drawings that head each chapter are well conceived. The text is entertaining and informative throughout — one can do no better than to repeat Newton's own tribute to L. Tinbergen's earlier Sparrowhawk study: "The whole work has a ring of credibility about it, and was obviously written by someone who knew Sparrowhawks and their prey extremely well."

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Waders, Their Breeding, Haunts, and Watchers

By Desmond and Maimie Nethersole-Thompson. 1986. Poyser (Buteo Books, Vermillion, South Dakota). 400 pp., illus. U.S. \$45.00.

"An endearing mish-mash for devotees" (Gillian Boyd). Poyser's list is justly esteemed. They publish well-written, well-illustrated, well-made books, at prices that are reasonable (at least in the U.K.). *Waders* is good to look at, illustrated with attractive drawings by that perceptive craftsman Donald Watson and with first-class full page or half page plates of 31 species of shorebirds, by 22 photographers. Most of the text and plates deals with Eurasian species not found in North America. Shorebird enthusiasts try to be cosmopolitan — witness the success of the Wader Study Group, with a membership drawn from all continents, and the International Waterfowl Research Bureau (IWRB), with its flourishing Palearctic and Western

Hemisphere Wader Working Groups (the latter led by a Canadian) — so that the emphasis on British-breeding species will not be a bar to them. The authors have also drawn on the knowledge of several Canadians to fill out their accounts of several species, such as knots and turnstones on which work in Canada has been especially detailed.

Enthusiasts are often not good on paper. Fortunately Desmond and Maimie Nethersole-Thompson write in an accurate as well as a lively way, so that wherever you may dip into the book you will be likely to keep on reading and to learn, or be reminded of, something worth knowing. As the blurb notes, "The core of the book is the comprehensive accounts of the biology and behaviour of 18 species of waders in their breeding haunts". These are usefully detailed and reliable. The unusually full accounts in the main text of the

voices of shorebirds are supplemented by an appendix of sonograms of songs and calls.

In the Preface, by two of the Thompsons' sons, and in the unusually full acknowledgments, a lot of emphasis is put on the help that other water-watchers have extended to the Nethersole-Thompsons. They also devote a whole chapter to the personalities, journeyings, and discoveries of the pioneer students of northern-breeding shorebirds, mostly British and mostly egg collectors, the amateur naturalists who dominated the field until the professional biologists arrived in the second half of the twentieth century. That change of players has brought many changes in approach, aided by great

improvements in equipment and in mobility. Fortunately, even professionals can be enthusiasts, a fact the authors list of correspondents makes clear. So, this book is a very good read and guide to what is now known. Some readers may recall E. C. Bentley's rhyming introduction to one of his books: "Mr. T. Werner Laurie is not at all sorry he undertook the publication of this instructive compilation". I hope that Mr. Trevor Poyser will find himself in the same agreeable state.

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Whitetail Country: The Photographic Life History of Whitetail Deer

By Daniel J. Cox and John J. Ozoga. 1988. Willow Creek Press, Wautoma, Wisconsin. ix + 145 pp., illus. U.S.\$39 plus U.S.\$2 shipping.

Whitetail Country began as a photographic history of White-tailed Deer in the northern woods of Wisconsin. Daniel Cox selected the best from over 5000 slides taken during five years of casual and two years full-time hunting deer with his camera. The photography alone would make the book worthwhile, both as a coffee-table display and as a unique insight into the very private lives and behaviour of these deer. Cox more than meets his aim to nurture through his photography an understanding of, and appreciation for, our natural resources and to stimulate his readers to understand the need for conservation of these resources for the enjoyment of future generations.

However, the photography is only half of what makes this book valuable. Equally inspiring are the most up-to-date technical and scientific insights into the behaviour and physiology of The White-tailed Deer provided by the text written separately by John Ozoga. His understanding of the deer through many years of research at the Michigan Department of Natural Resources Cusino enclosure in northern Michigan is presented in an interesting and informative manner which complements the artistic photography. In fact, I found it difficult to say which I enjoyed best or learned the most from.

The book is divided into the four seasons which totally dominate the behaviour of the whitetails, especially in our northern climate. Comments are also made on variations in behaviour in those which have adapted to life in the western deserts or as far south as the Amazon. Spring is the season of survival and rebirth. Intimate photographs of the

birthing and rearing of fawns provide portraits of a very private, secretive life around which Ozoga weaves his text on the trials and triumphs of this season. Summer is the time of plenty, when the deer can rest and build themselves up for the rigours of the autumn rut and winter cold which lie ahead. Interesting facts emerge throughout. Did you know that the whitetail buck antlers are "the fastest growing things known in the animal kingdom, sometimes increasing by a half an inch in a single day". Autumn is the rutting season when the dominant males rule the woods. Although gestures are usually enough to intimidate lesser males, sometimes bloody battles ensue resulting in serious injuries or even death. Winter is the time of survival of the fittest. The sick and undernourished are culled from the herd. This is also the time when the normally solitary to small monosexual family groups join together in "yards" of critical winter habitats. Interestingly, the adult males seem to leave the best yarding areas for the does and young.

I found this book an intriguing classic from both the artistic, photographic and the ecological, ethological perspectives. The publishers have done justice to the quality of the presentation as well. My only, very small, criticism is over the lack of discussion or caption for many of the photographs. Although they coincide well with the text it is obvious that this is not a direct collaboration. It would have been nice if Cox would have provided us with some captions to explain when, where, and how each photograph was taken.

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Breeding Birds of Ontario: Nidiology and Distribution, Volume 2: Passerines

By George K. Peck and Ross D. James. 1987. Royal Ontario Museum, Toronto. xi + 387 pp., illus. \$36.

This volume is the culmination of a massive undertaking by the authors to analyze and consolidate the information in the Ontario Nest Record Scheme, and to use these data as the basis for a comprehensive overview of the breeding birds of the Province. In the process they have also drawn on other available sources of information, including material gathered during the fieldwork for the *Atlas of the Breeding Birds of Ontario* (Cadman, Eagles, and Helleiner 1987). The two volumes together — Volume 1 was published in 1983, and is brought up-to-date in an appendix to the present volume — cover the 292 species for which breeding records exist, and represent a synthesis of almost 85 000 cards with data on over 326 800 nests, gathered over the course of more than 125 years. The scheme itself has been in operation for 31 years, and is yet another example of the health and vigour of Canadian ornithology.

Those familiar with the style and methods of Volume 1 will find this volume comfortable to work with, as the same approaches are used in the present work, which covers the 144 passerines that breed in the Province. The introduction does not repeat the detail in Volume 1, but does provide enough information to allow the book to be used without the need for constant back-references. It also repeats the maps, and significantly expands the detail for northern Ontario. The section of black-and-white photographs at the back is enlarged, but the major proportion of these are now valuable shots of nest and habitat, rather than simple poses of the birds themselves. Finally, a second appendix is a tabular display of the egg dates for all the species covered.

In both volumes each species is treated separately, with an outline map showing breeding status for each of the 52 provincial regions, and an outline — usually on the facing page — of the nidiology, followed by a concise summary statement of the species' breeding distribution. The nidiology section indicates the number of records and then provides as comprehensive an account of nest site, location and structure as the data allow. There follows a summary of egg data including cowbird parasitism, incubation period and egg dates. Many accounts are enlivened by vignettes by Ross James of the birds themselves.

It is appropriate to note some of the limitations inherent in the data upon which the work is based. Nest record cards are filled out voluntarily by

persons who are usually doing something else, and for many of us good intentions far exceed our actual production. The scheme works best when the nests are easy to find, the species are common, from locations where birdwatchers are numerous. For species and in areas where these conditions do not apply, the data thin out rapidly. Hence, no Chipping Sparrow records for Ontario's two easternmost counties, 6358 robin records versus 558 for Savannah Sparrow, and still only one undocumented nest of Connecticut Warbler. Similarly the interesting and valuable egg data are always much more limited than the total number of records: in the case of American Robin again, only 1581. Those who propose to work with the data must be conscious of these limitations, but they in no way should detract from what is a remarkable cooperative endeavour.

The present volumes, together with the appearance of the *Atlas* within months of the publication of this one, now provide Ontarians with an exceptional body of information on the Province's breeding birds. The two very different approaches used by these works are essentially complementary to one another. The strength of the *Atlas* is in showing the distribution of birds during the breeding season over the course of five years' intensive fieldwork, but it confines itself to generalized statements on the nests themselves and their locations. Peck and James, on the other hand, present a comprehensive picture of nidiology, gathered over an extensive period of time. If the *Atlas* procedures perhaps could imply that the extent of our knowledge is greater than it really is, an examination of the nidiology details quickly emphasizes the huge scope still remaining for fieldwork.

I found the body of the text pleasantly error-free, although the nature of the work makes errors hard to detect, and the index works well. The only minor inaccuracies I found were in the plant list, and I'd love to know if a Bobolink nest really was found in a clump of *Vicia benghalensis*!

A book of this kind is scarcely light reading, but it has its lighter moments, some of them neatly summarized by the authors in the *Introduction* as "unique or interesting information". A Tree Swallow nest in a howitzer barrel, 25 American Robin nests on the girders of a highway bridge, and a Great Crested Flycatcher nest containing a squirrel tail were some that caught my eye. You'll have to buy the book to find more, and I recommend that you do.

This is an outstanding achievement, and it is an indispensable reference work for anyone, professional or amateur, that is seriously interested in the breeding birds of Ontario. It should also be valuable to those studying the nidiology of species

that breed in the Province, even if they are working in a different region.

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BOTANY

Mushrooms of the Northeastern Woods: A Visual Guide

By Jean Hurley. 1987. Revised edition. Birchfield Books, North Conway, New Hampshire. 128 pp., illus. U.S.\$9.95.

This is a soft cover field guide illustrated by fairly crude black-and-white line drawings of 89 species. Although the illustrated mushrooms are recognizable to those with knowledge of the different species, it is the reader's familiarity with the mushrooms which fills in the gaps left in the illustrations and discussions. A novice could certainly make many mistakes.

The mushrooms are grouped by colors, presence of lamellae or other fertile structures, and features such as the presence of latex, an annulus, etc. The difficulty with this approach is the lack of colored illustrations. One has to carefully read all the color notes alongside each illustration. A specimen of *Hypomyces lactifluorum*, the Lobster Mushroom, a bright orange commonly collected parasite, on deformed mushrooms with poorly formed gills could easily be mistaken for a chanterelle which appears under the heading "ORANGE cap, very shallow gills." Since neither are poisonous nor harm

would be done by such as misdetermination, but this is only one example. Another difficulty would be distinguishing between boletes with a "smooth RED cap, pores" (p. 29) and "dark RED cap, pores" (p. 31), regardless of the species involved. The book will be most helpful to amateurs familiar with a variety of species, who are trying to recall just exactly what it was that characterized a species, say for example, *Rozites caperata*, the Gypsy Mushroom. Notations on frosting and corrugations on the cap mentioned in this book help to confirm the identification which the user already suspected.

Despite the shortcomings there are many interesting tidbits of information in the book. As a naturalist's note book, it is worth acquiring, but for the novice, a more comprehensive and better illustrated guide is recommended.

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ENVIRONMENT

The Wild Boglands: Bellamy's Ireland

By D. Bellamy. 1986. Facts on File Publications, New York. 178 pp., illus.

Second only to the Soviet Union in exploitable resources, and covering about 14% of the total surface area of the country, Canada's peatlands are a valuable and important part of our natural environment. *The Wild Boglands* is of interest to every Canadian.

The volume is divided into nine chapters, the titles of which cleverly reflect the popular style of the book. Chapters one through four consider the physical characteristics of peatlands. "Peat

Growing Wild" is the introductory chapter on peat and peatlands, "How to raise a bog", discusses the vegetation and development of raised bogs, "The Wet Blanket" is about blanket bogs, and "Salts of the Earth" discusses the water chemistry of the peatlands which is so important in peatland distribution and vegetation patterns.

The Irish bogs are well known for their long history of peat workings. Workmen digging the peatlands periodically encountered Giant Irish Elk bones, cadavres of prehistoric sacrifices, bog butter, or tree stumps and buried forests. All of

these finds have made the Irish bogs world famous. Bellamy devotes the next three chapters: "Taking down the evidence", "Evidence from under the blanket", and "The tale of the Little Red Bog", to discuss these topics in detail, and in particular, the development and paleoecological significance of the postglacial fossil record. The final two chapters emphasize the economic importance of the Irish peat deposits, "What can you do with a bog", and "Cut and thrust — Options for the future".

The book is a superb piece of work, which leaves little worthy of criticism. Dr. Bellamy's own research has focused for many years on the intricacies of peatlands. His love for peatlands, and specifically, for his own wild boglands in his homeland of Ireland is clearly reflected by his breadth of knowledge and command of the topics, and by the lucid manner he conveys complex phenomena with ease. The light, popular style makes the book readable by a wide spectrum of age groups of various educational backgrounds. Bellamy's vivid analogies accurately present concepts that might otherwise be difficult to get across to non-specialists, such as referring to peatlands as compost heaps, or considering the postglacial history of peat bog development as a story book, the pages of which have acted as blotting paper to soak up pollen grains recording events of the past.

The diagrams and numerous colour and black-and-white photographs are first rate, contributing to a high-quality product. The photographers, and Dr. Bellamy for his selection of photographs, are to be congratulated. In particular, I liked the "10,000 year calendar", colour landscape reconstructions from 10 000 to about 4 000 years ago (pp. 102-103). Truly a picture is worth 1000 words when it is of flora, fauna, and land features, the unique analogues of which either do not exist today or are not seen by most people.

The Wild Boglands is a great complement to two earlier, equally good books by Godwin (1978, 1981) on the peatlands of Britain. However for general reading, I prefer Bellamy's book for its lighter, less technical style. I applaud Dr. Bellamy and give him high marks for a book that everyone interested in peatlands should have on their book shelves.

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- Godwin, H. 1978. Fenland: its ancient past and uncertain future. Cambridge University Press, Cambridge. 196 pp.
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Evolution and Escalation: An Ecological History of Life

By Geerat J. Vermeij. 1987. Princeton University Press, Princeton. xv + 527 pp. U.S.\$47.50.

An Ecological History of Life covers a lot of possible territory. Others might use such a subtitle for volumes about biogeochemical cycles, the development of communities, or the biotic occupation of increasingly hostile environments, but when Vermeij uses it the reader knows the book will centre around the evidence that the shelly armour of marine invertebrates has evolved in response to predation. From this centre he defends the "Hypothesis of Escalation": that there has been general progressive evolution over the course of life, brought about by the adaptive responses of prey to the dangers posed by their competitors and predators; that "modern organisms may be no better adapted to their biological surroundings than ancient ones were to theirs, but the biological surroundings have themselves become more rigorous within a given habitat" (p. 4).

Twenty-five years ago it would have been absurd to doubt this hypothesis. It was assumed to be proven by histories of increased mechanical efficiency within lineages and by the diverse ecological roles of the descendants of adaptive radiations. There is still a certain absurdity in seriously pondering whether trilobites might be the competitive equals of crabs, but modern models of punctuated equilibrium, species selection, vicariance, and mass extinction have cast doubt on the generality of the "Hypothesis of Escalation". If species are born in little bursts of change, if the likelihood of their emergence is dependent on factors unrelated to their adaptations, if the fauna of an area results from passive rafting by continental drift, and if survival though unpredictable mass extinctions is both unlikely and unrelated to the adaptations that are ordinarily important, then perhaps there has not been any "real progress," and the archaic appearance of old faunas is just due to the presence in them of taxa

that by chance have become extinct. So it is not a new idea that this book examines; it defends an hypothesis as old as Lamarck against new challenges, and with a new kind of data.

If lineages can come and go for non-adaptive reasons, then one cannot evaluate the "Hypothesis of Escalation" within particular lineages, but must compare the inhabitants of similar habitats through time for evidence of overall changes in predation or competition and of defences against them. Two contrasting cases are those of marine drilling and of plants, the first the best trial of Vermeij's method, and the second the most patently uncomplicated.

Some mollusks drill holes in their prey by corrosion or abrasion. Successful, failed, and absent drill holes are impartially preserved in fossils, so one can assess both the frequency of attempted drilling and its success. The shallow marine habitats where drilling is important are severely decimated by mass extinctions, so a secular increase in drilling reflects generally more intense interactions rather than the evolution of particular lineages. Drilling seems to have first been a major cause of death for bivalves and gastropods in the Eocene. Since then the frequency of drilling and the success of pelecypods in escaping has been roughly constant in the populations studied, though there is a great scatter in the data. Far too few assemblages of species have been studied (19 in Figure 11.2), especially in the Mesozoic and Paleozoic, and the data are clumsily, I think, presented as "the percentage of species in which the frequency of drilling exceeds 0.10." I am not sure how such data should be analyzed, but I am sure that more could be made of them than this.

The intensity of herbivory cannot be measured from fossils, but much of the gross morphology of plants is clearly an expression of their attempts to reach light and water before their neighbours. They have been much less affected by mass

extinctions; more extinctions can be attributed to competitive exclusion, and the development of stems, roots, leaves, water conducting vessels, seeds, and free sprouting all give lineages obvious advantages over competing species.

In a book about the search for trends and breaks in trend lines, it would have been appropriate to uniformly apply some technique of nonparametric trend analysis to the sets of data. Those that span more than 100 million years could have been plotted on a common time axis to make the figures more comparable, and breaks in the trends could have been summed to identify common periods of change. As it is, the data and discussion come at the reader in a confusion of cited studies and facts, with few statistical tests of differences between samples or the significance of trends.

It is a relief to find a book of such scope that does not end with a sappy chapter about the evolution of people, though Vermeij does drop hints about the similarity between futile biological arms races and the technological arms races now being conducted (no less deterministic word seems appropriate) by our own species. Vermeij published a similar, less paleontologic and less general, book in 1978 (*Biogeography and Adaptation: Patterns of Marine Life*. Harvard University Press. xi + 332 pp.), and the timeliness of the present volume is evident from its bibliography: of the 1630 titles cited, more than half are dated after the publication of the previous book.

This book and its predecessor are important and fascinating works, swarming with new evolutionary ideas. I hope that Vermeij will have to write another after another decade (perhaps in consultation with a graphical data analyst).

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The First Resource: Wild Species in the North American Economy

By Christine Prescott-Allen and Robert Prescott-Allen. 1987. Yale University Press, New Haven. 529 pp., illus. U.S.\$62.

Robert Prescott-Allen is the man who brought together information from a myriad of sources and actually wrote the *World Conservation Strategy* (although this is not well known since his name appears only once in the *Strategy*, buried at the

bottom of the acknowledgements). The *Strategy* is a much-admired and intellectually satisfying plan for ensuring sustainable development of the biosphere by reconciling conservation with economic development.

The *Strategy* uses an overtly utilitarian outlook; that is, it emphasizes how biological conservation is a matter of rational self-interest for the human

species. There are at least two possible problems with this approach. *The First Resource* mentions both of these problems, and goes some way towards solving one of them.

The first problem is that data on the actual economic contribution of wild species are scarce. The Prescott-Allens here collect and present data on the significance of wild plants and animals to the economy of the United States (with some contributions from Canada as well). The data are presented in a systematic way, as yearly averages from the period 1976-1980 (with a few unavoidable exceptions) with suitable qualifications so that they can be used in quantitative comparisons with data taken at different times in different parts of the world. The book is full of tables of data with complete references to their sources. It is all very impressive. For the record, the bottom line is that at least 4.5% of the American GDP (gross domestic product) can be ascribed to use of wild species, with logging of non-plantation trees being the major contributor.

The second problem with a utilitarian perspective is that it may be a sell-out of "real" con-

servation principles. To some, it is morally offensive to put a monetary value on our fellow inhabitants of the biosphere. The Prescott-Allens deal sympathetically with this and other objections in the Introduction, but persevere in their project with the attitude that it can't hurt, and may well help the cause of conservation. They argue that, just as one can assign a market value to a house without denigrating its non-economic values as a home, so also can one speak of the economic value of wild species without implying that these are the only or the major values of wildlife.

The ethical question will continue to exercise philosophers and responsible conservationists for years to come. Meanwhile, for those who have not ruled out utilitarian arguments as at least part of their arsenal, *The First Resource* is likely to be a frequently-used reference.

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The Northwoods Wildlife Region

By Jay and Constance Conrader. 1984. Naturegraph Publishers, Happy Camp, California. 188 pp., illus.

This book attempts to be an "all-in-one" field guide to the plants, mammals, birds, reptiles, and amphibians of an ill-defined area called the "Northwoods". While its intended purpose is to "provide simple descriptions of indigenous plants and animals . . . so that they may be recognized and called by name", the reader may in fact find himself searching out the Latin name of each plant or animal in order to identify the description.

Six introductory chapters, dealing with geology and soils and five very generalized habitats, are more polemic than useful. The chapter on plants while being the one chapter that is adequately illustrated, suffers from the usual syndrome of field guides which only list plant descriptions — if you don't know what it is you can't find it in the guide; if you do know what it is the guide isn't particularly useful. And this one really isn't.

The chapters on the terrestrial vertebrates are disappointing in that they contain only the barest verbal descriptions, and nothing to alert the reader to distinguishing marks or similar species. There is

nothing on the ecology or life history of each beast. The illustrator's ability has also been taxed in these sections. While the pen and ink sketches of the birds are least accurate (if not terribly useful for identification) some of the mammal drawings approach the quality of nineteenth century photogravure that has in recent years been repopularized in the medium of rubber stamps.

I have never been enamoured of the encyclopedic style of field book which tries to describe everything. Rather than being the one book you could take to the field they have always been, to me at least, the resource of last resort. Still some of these "all-in-one" guides have been surprisingly eclectic treasures of miscellany. The reader looking for such a guide might do better with Collins's (1959) *Complete Guide to American Wildlife* or with Palmer's (1949) *Fieldbook of Natural History*.

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Handbook of the Canadian Rockies: Geology, Plants, Animals, History, and Recreation from Waterton/Glacier to the Yukon

By B. Gadd. 1986. Corax Press, Jasper. 876 pp., illustrated. \$25.00

I can almost hear you saying "oh no, not *another* guide to the Rocky Mountains!". But hold on a minute; this one is different and is well worth considering.

The author had put almost two decades of first hand experience in the mountains into the approach for this book. It offers (to paraphrase Gadd's own words) the things you need to know to enjoy the mountains properly. It's an extremely ambitious concept and one that has defeated previous attempts. This time, though, I think it worked.

The book is an excellent physical product, well bound and with a durable Kivar cover. It was constructed specifically to withstand the abuse of life in a hiker's backpack. The paper is thin but is surprisingly strong. The type is 9 point. That is too small for easy reading of technical material, especially under field conditions. This was, I assume, a compromise between economy and readability. There are hundreds of small but clearly reproduced pen and ink sketches to illustrate the text. Many of the images in the 15 pages of colour habitat scenes, however, are poorly rendered (in my copy at least). The type for their overly complex captions are ridiculously small; some readers will literally require a magnifying glass. At 8½ by 5½ inches, however, the book is a good size and is well put together for field use.

There is a huge (260 page) detailed earth science section starting things off. It begins with plate tectonics and ends with a treatment of the dynamics of modern climatic processes. This is very much a book onto itself and delves deeply (pun intended) into bedrock stratigraphy, tectonic processes and so on. Many effective photographs and pen and ink sketches accompany this text.

Gadd offers the user (perhaps a better term than 'reader') a review of the distribution, status and habitat of all regularly occurring fish, birds, mammals, butterflies, amphibians, and reptiles. A less detailed treatment of non-vascular plants and invertebrates is also included. There are probably close to 2000 species covered here. Most are illustrated (well for most plants, mammal skulls and tracks, fungi, insects, and other invertebrates, acceptably for most fish, mammals, and large birds, but inadequately for small birds). The descriptions of morphology, range and behaviour are usually competent, if somewhat dated by the use of older literature (e.g. *Habenaria* in Orchidaceae). Gadd's

personal experience enhances many of these discussions. His language style is intentionally light — even flippant in places — and that helps the reader work through the mass of information. Since the book is also intended to be a reference source, major synonyms and authorities for names would have been helpful with some groups.

A large section on precautions, hiking techniques, first aid, a "must see" areas list, and other "how to" information follows, accompanying a series of contour maps of the Rocky Mountains. A well done index concludes the book.

My only major complaint with the *Handbook* is that it goes into too much detail in some areas. The earth science section is an obvious example of this; it is excessively long and complex for a general public guide. It is all well and good too, to describe the concept of cross-country skiing in this landscape, but do we need instructions on how to perform certain turns? I think not. This unnecessary detail discourages the casual naturalist and other users from reading some of the larger sections. It encourages the use of the *Handbook* as a reference source only . . . and to satisfy that need, *more* detail would be required. The balance between fact and feeling (always a difficult judgement in a popular guide) seems weighted too heavily towards fact to satisfy the general hiker and not heavily enough for the real keeners. The *Handbook* would likely have benefitted by a 20% reduction (or more ?) in the text, forcing the author to focus more clearly on the general audience.

Despite the overly detailed geological treatment and general verbal excess, Ben Gadd has produced a book that *will* be used successfully by hikers and naturalists throughout the Rocky Mountains — and that is no small achievement. It offers an excellent introduction to several disciplines and will undoubtedly help springboard many casually interested hikers into deeper studies. It also provides an excellent initial reference for anyone even marginally interested in the Rockies.

In his preface Gadd expressed the hope that this labour of love would be good for the Rocky Mountains. I believe that it is, as well as for the naturalists who enjoy them.

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Fertilizer in America: From Waste Recycling to Resource Exploitation

By Richard A. Wines. 1985. Temple University Press, Philadelphia. vii + 247 pp. U.S.\$34.95.

This is the history of only half of the title subject: the Brown University Ph.D. dissertation from which it is drawn was, more accurately, called *From Recycled Wastes to Commercial Fertilizers: The Evolution of a Technological System in the Eastern United States, 1800-1880*. It was after 1880, when fertilizers were available in large quantities and consistent quality, that they could have a major effect on the ecology of the lands where they were used. But there are only meagre words here about the industrial fixation of nitrogen and the modern agribusiness industry, and there is no emphasis on the contribution of fertilizers to nutrient flows through either agricultural production or the total landscape. There are no measures of how important fertilizers were to regional ecologies, or of what fraction of the nutrients in agricultural produce was captured by recycling. This is a narrative industrial history rather than a quantitative ecological history.

The style reminds one of the old instructions for preachers: "Tell them what you're going to tell them, tell them what you're telling them, and then tell them what you've told them." The theme of recycling giving way to exploitation is often repeated, and the smoothness of the writing leaves the feeling that even the body of the text is an abstract. Even 51 pages of notes do not give the kind of detail which would leave the reader with the smell or feel of the fertilizers, and one wonders if many of these pages might have been saved by adopting the author-date system of citation.

The pioneer response to the exhaustion of soil nutrients was to abandon land and move to frontier areas or into industrializing cities. These cities might draw their wheat and meat from distant, newly settled soils, but they had to obtain hay and vegetables from a radius of a few tens of miles, so it was farmers near cities who first purchased fertilizers: manure, ash, bones, blood and offal, night soil, street sweepings, tanbark, gypsum, and marls. Early Nineteenth Century agricultural theory emphasized the maintenance of

soil fertility by the return of all animal and vegetable waste to the soil, and the exchange of produce for urban wastes was seen as an extension of this recycling from an on-farm to a regional scale.

The notion of recycling was further extended, with biogeochemical naiveté, to products of the sea. Nutrients flushed down rivers were thought to be returned to the land by marine-based fertilizers. These included nitrogen-rich Peruvian bird guano, phosphate-rich bird guanos pirated from Pacific and Carribean islands under the erratic protection of U.S. legislation, primitive superphosphates manufactured from phosphate guanos and from bones, and fish waste from the production of Menhaden oil. These products, in turn, accustomed farmers to concentrated fertilizers from remote sources, so that the discovery of fossil phosphate rocks, and their substitution for guanos and bones in superphosphate, did not change the use of fertilizers except by leading to increased quality and production. The ideal of recycling was thereby abandoned, and farmers exchanged the pioneers' mining of newly broken soils for the commercial mining of phosphate, potash, and the natural gas to fix nitrogen.

The failure of the recycling ideal led to the depletion of organic matter in soils, and turned farming from an ecological to a commercial enterprise. This encouraged trends toward soil erosion, pesticide-sustained monoculture, and the hydroponic put-and-take of modern corn-and-soybeans agriculture. Naturalists who have fought in the long defeat of ecological conservation will recognize this pattern: an essential ideal that seemed to be well established in public policy slipping away under the influence of easy substitution, economic expansion, and flush-toilet convenience.

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Modeling Nature: Episodes in the History of Population Ecology

By Sharon E. Kingsland. 1985. The Chicago University Press, Chicago and London. 267 pp., illus. U.S.\$27.50.

This book guides the reader through a period in history during which the foundation for modern population ecology was set down. The author concentrates on the theoretical side of the development of the field of animal population ecology between the turn of the century and the 1970s in an effort to demonstrate the evolution of the science, which had its beginnings in other disciplines such as physics, chemistry, and statistics. In addition, Kingsland incorporates biographical sketches of the principle scientists involved in the development of this field. In this review, I mention only a few of the scientists identified by Kingsland.

In Chapter 1, Kingsland describes some of the leading concepts in ecology by introducing some of the problems of population analyses. The work of Alfred J. Lotka, who embraced a vision "of man as an active part of the cosmos", is discussed in detail. The second chapter focuses on Lotka's book, *Elements of Physical Biology*, which was published in 1925.

Chapter 3, entitled "The Quantity of Life", reviews the evolution of economic entomology, the concept of biological control, and the degree to which the need to manage insect populations functioned as a catalyst to promote advancement in animal population ecology. Kingsland also reviews the work of Charles S. Elton, who drew attention to the need for ecologists to study fluctuations in mammal populations, and Raymond S. Pearl who applied the logistic (S-shaped) curve to animal populations. Chapter 4 is an extension of the previous chapter whereby the author reviews the logistic curve, the debate surrounding it, and progress in the field because of it. The collaboration between Pearl and Lotka is also discussed.

Chapter 5 explores mathematical modeling of nature, particularly animal populations. The Lotka-Volterra relationship is described. Among others, the work of Alexander J. Nicholson is

discussed in the context of his effort to develop a theory of population regulation and competition.

In Chapter 6, Kingsland reviews the ecologist's responses to the work completed in mathematical ecology in the 1920s and 1930s. This chapter is particularly interesting because it exposes the debate and conflict associated with the introduction of new concepts which displaced older, well established theories and field techniques.

"The Niche, The Community, And Evolution" is the title of Chapter 7. The author discusses how mathematical theory influenced the development of key issues in ecology and evolutionary biology. The work of Georgii F. Gause and David L. Lack is reviewed. Gause completed experimental studies based on Volterra's models in an attempt to integrate ecological and evolutionary processes. It is followed with a review of the work completed by George E. Hutchinson, who employed Gause's results to promote his own ideas about competition and niche theory.

The work of Robert H. MacArthur is described in Chapter 8. MacArthur modernized animal population ecology by functioning as a catalyst of new debates which focused on the place of theoretical reasoning in a descriptive and applied science. Hutchinson's work on the niche and island biogeography is also discussed.

Kingsland concludes the book by summarizing the major issues addressed in the previous chapters. The book contains reference notes to statements made throughout, a select bibliography, and an index. It is without question an erudite review of episodes in the history of population ecology; however, I recommend it only to professionals who have a complete grasp of the theories of population ecology and to those interested in the history of this field.

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The Naturalist's Year: 24 Outdoor Explorations

By Scott Camazine. 1987. Wiley, New York. xv + 287 pp., illus. U.S.\$14.95.

Teachers, park interpreters, youth leaders, and parents should take careful note of this book

written by an M.D. who is a Visiting Fellow in the Biology Department at Cornell University.

The world needs more books like it. We must be shown how to see and understand the rock and life

around us, but most of us never do learn well. We look but rarely really take in what we see. Even the current stampede of millions of people in affluent countries to wild places has a frightening superficiality about much of it. It is dominated by two groups, it seems, the birders and hikers. Millions of birders see birds as primarily check marks for checklists, adding points to the day's score of species encountered. Even larger numbers of hikers seem to exhibit more stamina and special equipment than understanding of the countryside they hurry through.

Unfortunately, wild places trampled by crowds of people are soon no longer wild. A successful rally to promote saving an alpine meadow from commercial destruction destroys the meadow when the rally is held in it, and popular birding places can be heavily damaged by the mass pursuit of birds.

In contrast, there can be little or no damage and much more excitement and challenge from exploring one's own yard, or the corner of an abandoned field near town. Much more can be seen on one's knees than when striding through the fragile wilds. The shelves in good book stores are heavy with guides identifying species from Thailand birds to Australian reef fish, and even heavier with guides charting almost every step for hiking through the nearest large municipal park as well as through Nepal. Without doubt these are useful. Popular guides to deeper understandings are scarce, however. More are overdue. Most of us are missing the play, being preoccupied with the stage itself or at best with only naming the actors.

The slim volume under review is dedicated to showing people how to really see and understand the natural world's detail, at home and close to it. Twenty-four topics of high interest around a year are introduced by proposing 58 activities, most of them easily done, some of them experiments, the rest close observations of natural situations. I wish

I had found a book like this in my high school years to direct my curiosity into wild lives. Without help I only glimpsed many of them or missed them entirely; but all is not lost, for I can still use it to open the eyes of minds of grandchildren, and I expect to have just as much fun with it as they do.

Subjects explored range from skunk cabbage to house flies, from deserts to freshwater ponds, from skeletons to snow. Brief but highly informative texts lead into each chapter. Did you know that bees must fly 50 000 miles, equal to twice around the world, to make one pound of honey? That the flowers of skunk cabbage are heated to a constant 22°C as the plant pushes up through the icy snow in springtime?

The hands-on activities outlined are no less attractive. There is help here for finding mating salamanders, seeing the stomata on leaves, examining a mushroom, populating an aquarium with local wild lives, experimenting with seeds that fly, studying spiders, extracting colours from autumn leaves, finding and clearing fossils, making snowdrifts, and others just as interesting.

Some 149 excellent drawings and twenty good photographs enliven the text and also aid the explorations proposed. Praises must also be sung for each chapter ending with a list of publications for deeper digging into the areas of discovery suggested. So often this necessity is ignored. When the mental appetite is hungry for more it should be fed at once, or it soon dies for want of knowing what to do next.

The writing is carefully accurate, the thinking is stimulating, and there is a sureness throughout the text which must have come from frequent polishings after leading people into the subjects presented. In all respects this is a book well done. Even the price is right.

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MISCELLANEOUS

Rideau Waterway

By Robert Legget. 1986. Second edition. University of Toronto Press, Toronto. 312 pp., illus. Cloth \$30; paper \$14.95.

The Rideau Canal and Rideau River make Ottawa the beautiful city that it is. However, the history of this canal, the men who worked on its construction, and the reason for its being are

barely known to the residents. The rest of this waterway connecting Ottawa to Kingston is also pretty much taken for granted by the many pleasure boaters who now ply through the system.

Robert Legget has written an engrossing account of the development of this waterway, complete with informative maps and historical

perspectives. This waterway, as he explains, is a natural series of lakes and rivers which were made navigable by the suitable and careful addition of locks and channels. It was built from 1826 to 1832 to provide a safe route between Kingston and Montreal, thus avoiding the St. Lawrence River and the potential threat of the American army. The book also contains a detailed guide through the entire waterway. It is a handy reference for a boat trip from Kingston to Ottawa, or points in between. It will make the route come alive. The military imperative for constructing such a route is made clear, as is the engineering skill of the man who oversaw the whole construction.

Legget was the first Director of the Division of Building Research of the National Research Council of Canada. His admiration of the work of Lieutenant Colonel By is communicated to the reader. But Legget tells us much more than the professional skills of the man. He fleshes out John By the family man, a man who is equally concerned with the men under his charge as he is of the quality, and yes, the cost of the construction of the canal. Lieutenant Colonel By was not fully appreciated in his time, and perhaps also not in ours. The author seeks to redress this oversight with the publication of this book.

It was an enormous undertaking to construct this navigable route through poorly charted and densely vegetated country. The horrendous problems which it entailed are lucidly told in the narrative. Anecdotes from the past are woven together with features to be seen and appreciated along the route today. Highlights of the construction of the canal, particularly the placement and arrangement of locks, are featured, and interesting aspects of the natural history are mentioned. We are taken through both a historical and a contemporary tour of the entire Rideau waterway.

Ironically, that route so painstakingly forged through almost uninhabited country is now the heart of a thriving tourist region and the domain of pleasure boaters. Happily it never was an important military route as first planned, but it was an important commercial route until the advent of the train and motorized travel. And the author traces this development and the growth of the communities which sprang up along the canal route. The most famous of these being of course Ottawa, originally dubbed Bytown and later chosen as the capital.

This, the second edition, has been enriched with many more photographs and has been brought up to date by the inclusion of more recent constructions associated with the waterway such as the Carillon hydroelectric project, the St. Lawrence Seaway, and several new roads and bridges. The appendices have also been revised to include the latest maps, charts, fishing information, and a table of mileages, lifts, and clearances which would be of particular concern to boaters. My only quibble is the lack of metric equivalents. The text is not burdened by footnotes, instead the bibliography is divided into subject areas making it relatively easier to check or pursue further information. The inclusion of an index makes this book a very flexible guide to be used anywhere along the route.

I recommend this book whole-heartedly to all who live or play in or near the Rideau Waterway. It will stimulate your interest in the history of the area and give you a greater appreciation of this treasure of eastern Ontario. The paperback edition is small enough to be tucked into a canoe pack and is enhanced with a beautiful cover photograph, by Malek, of the final descent of the Rideau Canal into the Ottawa River.

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Seven Clues to the Origin of Life: A Scientific Detective Story

By A. Graham Cairns-Smith. 1985. Cambridge University Press, Cambridge. xi + 131 pp., illus. U.S.\$17.95.

The seven clues to the origin of life are: 1) from biology: genetic information is the only thing that can evolve through natural selection because it is the only thing that passes between generations over the long term; 2) from biochemistry: DNA is a suburban molecule far from the centre of the present biochemical pathways; 3) from the building trade: to make an arch of stones needs

scaffolding to support the stones before they are all in place and can support each other; 4) from the nature of ropes: none of the fibres in a rope has to stretch from one end to the other — organisms based on one genetic material could gradually evolve into organisms based on an entirely different genetic material; 5) from the history of technology: primitive machinery is usually different in its design approach and materials of construction from later, advanced, machinery; 6)

from chemistry: crystals put themselves together in ways that might be suitable for 'low-tech' genetic materials; and 7) from geology: the Earth makes clay all the time.

Cairn-Smith's conclusion is that biochemical life as we know it originated around a now-abandoned scaffolding of self-replicating clay-crystallization 'patterns' which evolved into "organisms". He recognizes that the problem with the origin of life is to start natural selection as early as possible, because it is the only force that can produce the teleomorphic processes characteristic of life. He finds in the variable ionic content and crystallization patterns of clay a system in which gene-like and adaptive patterns might propagate, and which could come to be assisted by a carbon-based metabolism that would ultimately free itself as a precursor to the procaryotic cell.

This is a popularization of the author's *Genetic Takeover*, decorated with quotes from the fictional Victorian detective Sherlock Holmes, and cast in the kind of reasoning Holmes might have used to reach the author's conclusions about clay organisms. This

sounds gimmicky, and I was prepared to dislike it, because too much reading of scientific literature has made me shy of anything that is not prefaced by an abstract. Often an author's refusal to let a reader know how something is going to come out has proven to be a sign that it was not worth waiting for, and mystery fiction is the nadir of such writing.

I found this book to be clearly written, reasonable, a pleasure to read, and not too secretive about the conclusion that clay-did-it (at least if one knew, from reviews of *Genetic Takeover* or a sneak view of Chapter 15, that this was the outcome). I like this story as a scenario for the origin of life, because it is so stalwartly Darwinian, but I think it is weakened by the failure to predict the fossils of the clay organisms — surely the biggest operational virtue of this story is that its ancestral organisms are pre-mineralized.

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The American Hunting Myth

By Ron Baker. 1985. Vantage Press, New York. xvi + 287 pp. U.S.\$10.95.

Hunting is a favorite outdoor pastime for millions of North Americans. As a result of this popularity, vast amounts of money are infused into local economies and government treasuries through equipment sales, taxes, licencing fees, accomodation, and travel. Government agencies have been developed to promote, monitor, and regulate hunting. Hunters have formed effective lobby groups to represent their views to elected officials. Against this powerful hunting establishment, however, there is a small, but increasingly vocal, group that believes sport hunting is an unacceptable outrage, cruelly perpetrated by man against wild animals. In *The American Hunting Myth*, Ron Baker launches an eloquent frontal assault on the institution of sport hunting, the hunting fraternity, and what he sees as the hunter-dominated government wildlife agencies.

Baker believes that all wild animals should be free from any exploitation by man. He frankly questions the ethics and morality of our modern society for still permitting, even encouraging, sport and trophy hunting while ridiculing animal rights activists. To support his contentions, Baker extensively documents many ways in which legal

forms of hunting and wildlife management have adversely affected both ecosystems and hunted species. He depicts modern wildlife management as a monumental failure, an environmentally-destructive means of elevating populations of game animals to artificially high levels for the benefit of the hunters. He sees government wildlife biologists and managers as being interested primarily in keeping the hunters, to whom they owe their jobs, happy. Baker suggests that this entire approach is propagated through college and university wildlife programs that teach job-hungry students to view wildlife as a harvestable crop and hunting as a biologically legitimate activity. This indictment is sure to rankle government wildlife biologists everywhere.

As an alternative to this present system, Baker ambitiously proposes a new, more humane environmental ethic, characterized not by exploitation but by a humane respect and reverence for life. He advocates a complete phasing out of sport hunting in favour of more constructive and ecologically sound wildlife management practices. Restructured government wildlife agencies would feature the replacement of wildlife biologists with ecologists committed to a more holistic view of wildlife and wilderness.

The American Hunting Myth is broadly divided into three sections. The first documents the perceived shortcomings of modern wildlife management; the second presents detailed analyses of seventeen arguments commonly used to justify sport hunting and game management. Baker's intention is to systematically and thoroughly debunk each of these arguments. They run the gamut from the biologically-based "Starvation Argument" (populations of game animals often exceed the carrying capacity of their habitat, so hunters are actually saving these unfortunate animals from winter starvation) to the ethically-based "Biblical Argument" (because God gave man dominion over all other living things, hunting then has important biblical support). The final section discusses the social implications of wildlife exploitation and presents Baker's specific recommendations for remedying this situation, including tightening hunting eligibility requirements, reducing the land base available for hunting, and the formation of ecological advisory boards to develop new, positive policies and regulations for each species. An appendix of suggestions for personal involvement and some notes to expand on several topics conclude the book.

Technically, the hardcover version of this book is well bound and should be able to stand up to the extensive use that wildlife activists will probably make of it. The text is well researched and effectively annotated with quotes from well-known animal activists. One small and admittedly trivial point, but whoever decided on what types of print to use in this book might have gone a little overboard. For example, on page 55, I counted

eight different combinations of print sizes and styles. I suspect one purpose of this variety is to emphasize the logical hierarchy of the text but the result is a little confusing (Let's see, if this section has medium-sized, capitalized, non-boldfaced, and non-italicized print, it must be . . . "the Hunter's Argument").

If nothing else, Baker is to be admired for standing up for what he believes in and for taking on such a powerful and socially-entrenched institution as hunting. His writing is filled with the passion of a strongly held view. However, the author's confrontational approach and dogmatic tone can only serve to heighten the antagonism between the two groups. Unfortunately, Baker also fails to recognize and build on any common ground that both hunters and non-hunters could share in, such as battling many of the serious environmental problems that threaten us today.

I recommend this book for anyone interested in the activity of sport hunting. Although most of the material is drawn from the United States, many of the principles discussed are equally applicable in Canada. Hunters should find interesting reading about how others see them and their "sport". Wildlife biologists might also see that their public image could use some polishing. In any case, some of the accusations and arguments set forth in *The American Hunting Myth* may strike a little too close to home for many of the members of the hunting establishment. I'm looking forward to their response to this challenge.

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Audubon Reader, The Best Writings of John James Audubon

Edited by Scott Russel Saunders. 1986. Indiana University Press, Bloomington.

The Bicentennial of John James Audubon

Alton A. Lindsey. Indiana University Press, Bloomington. 175 pp. U.S. \$17.50.

For many, the name John James Audubon is synonymous with exquisitely-crafted bird illustrations that were unrivalled during their time — and even now — for their vibrancy and attention to detail. According to two recent publications in commemoration of the bicentennial of Audubon's

birth, this legacy is too narrow and in need of updating, particularly in light of the world that Americans live in today.

In *Audubon Reader*, editor Scott Russell Sanders suggests that Audubon was a great writer in the same class as such noted early nineteenth century literary figures as Herman Melville and James Fenimore Cooper. In fact, Audubon's firsthand experience with the natural life of the

retreating American wilderness instilled in his writing a vitality and freshness that has seldom been matched. To support this contention, Sanders has assembled a representative collection of Audubon's writing from his *Ornithological Biographies* and notebooks and letters. The descriptions of his various travels, including a trip to Labrador in 1833, and his observations on bird life make for interesting reading. But they do not justify Sander's assertion that Audubon's writing "provided us with the most comprehensive view of our continent anyone had ever achieved".

Alton Lindsey's *The Bicentennial of John James Audubon* goes even further in its praise of Audubon, suggesting that the painter was one of two great acquisitions from France in 1803 — the other being the Louisiana purchase. This tone pervades the book which is little more than an

uncritical celebration of the man and his times. The chapters yearn for the days of the "freshly minted American continent" that Audubon knew and portrayed. Lindsey would probably go back in time if he had the chance.

In the hands of these two authors, then, John James Audubon has joined a long line of American folk heroes — in his case, a representative of the pristine American frontier and a way of life that is gone forever. Adulation aside, serious students of the history of science would be better served by consulting existing Audubon biographies.

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NEW TITLES

Zoology

- *The art of survival/la survivance et l'art.** 1987. Edited by Raymonde Lanthier. Canadian Wildlife Associates, Waterloo, Ontario. 64 pp., illus. Cloth \$21.95; paper \$11.95; signature edition \$1500.00.
- *The atlas of breeding birds in New York State.** 1988. Edited by Robert R. Andrle and Janet R. Carroll. Cornell University Press, Ithaca. 576 pp., illus. U.S.\$29.95; map overlays U.S.\$9.95.
- The biogeography of the herpetofauna of the pine-oak woodlands of the Sierra Madre Occidental of Mexico.** 1987. By James R. McCranie and Larry David Wilson. Milwaukee Public Museum, Milwaukee. 30 pp., illus. U.S.\$5.95.
- The biology of the honeybee.** 1987. Mark L. Winston, Harvard University Press, Cambridge. 281 pp., illus. U.S.\$29.95.
- †**The birds of the Fraser River delta: populations, ecology, and international significance.** 1987. Occasional Paper No. 65. Canadian Wildlife Service, Ottawa. 73 pp., illus. Free.
- A bird watchers' guide to Nepal.** 1987. By Carole Inskipp. Natural History Book Service, Totnes, England. 116 pp., illus. £8.75.
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- The butterflies of Indiana.** 1987. By Ernest M. Shull. Indiana University Press, Bloomington. viii + 262 pp., illus + plates. U.S.\$25.
- Butterflies of the lower Florida keys.** 1987. By Albert Schwartz. Milwaukee Public Museum, Milwaukee. U.S.\$5.95.
- A check-list of West Indian amphibians and reptiles.** 1988. By Albert Schwartz and Robert W. Henderson. Milwaukee Public Museum, Milwaukee. U.S.\$14.95.
- Crayfishes and shrimp of Wisconsin.** 1988. By H. H. Hobbs III and Joan P. Jass. Milwaukee Public Museum, Milwaukee. 176 pp., illus. U.S.\$14.95.
- Current ornithology, volume 5.** 1988. Edited by Richard F. Johnston. Plenum, New York. c394 pp. U.S.\$59.
- Dinosaurs past and present, volume 1.** 1987. Edited by Sylvia J. Czerkas and Everett C. Olson. Natural History Museum of Los Angeles County, Los Angeles and University of Washington Press, Seattle. xvi + 161 pp., illus. U.S.\$35.
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- Eagles of North America.** 1987. By Candace Savage. Western Producer Prairie Books, Saskatoon. 127 pp., illus. \$24.95.
- †**Extinct birds.** 1988. By Erroll Fuller. Facts on File, New York. 256 pp., illus. U.S.\$35 (no Canadian rights).
- Guide to identification of amphibians and reptiles of the West Indies (exclusive of Hispaniola).** 1985. By Albert Schwartz and Robert W. Henderson. Milwaukee Public Museum, Milwaukee. 176 pp., illus. U.S.\$29.95.
- *Immature insects, volume 2.** 1988. Edited by Frederick W. Stehr. Kendall/Hunt, Dubuque, Iowa. xiv + 754 pp., illus. U.S.\$69.95.
- The koala: a natural history.** 1988. By Anthony Lee and Roger Martin. New South Wales University Press, Randwick, Australia. A\$9.95.
- †**The Kookaburra's song: exploring animal behavior in Australia.** 1988. By John Alcock. University of Arizona Press, Tucson. 200 pp., illus. U.S.\$19.95.
- Little penguin: fairy penguins in Australia.** 1988. By Colin Stahel and Rosemary Gales. New South Wales University Press, Randwick, Australia. A\$11.95.
- Natural history of vampire bats.** 1988. Edited by Arthur M. Greenhall and Uwe Schmidt. CRC Press, Boca Raton, Florida. c272 pp. cU.S.\$145 in United States, cU.S.\$170 elsewhere.
- Nautilus: the biology and paleobiology of a living fossil.** 1988. Edited by Neil H. Landman and W. Bruce Saunders. Plenum, New York. c622 pp. U.S.\$95.
- New England wildlife: habitat, natural history, and distribution.** 1987. By the U.S. Department of Agriculture. U.S. Superintendent of Documents, Washington. 491 pp., illus. U.S.\$23 plus 25% foreign charge.
- *Philosophy and practice of wildlife management.** 1987. By F. F. Gilbert and D. G. Dodds. Krieger, Malabar, Florida. 292 pp., illus. U.S.\$24.50.
- Raptor management techniques manual.** 1987. Edited by B. A. Giron Pendleton, B. A. Millsap, K. W. Cline, and D. M. Bird. National Wildlife Federation, Washington. 420 pp. U.S.\$30.

Reptiles of the upper Amazon Basin, Iquitos Region, Peru: Part 1, lizards and amphisbaenians; part 2 — crocodilians, turtles, and snakes. 1986. Second revised edition. By James R. Dixon and Pekka Soini. Milwaukee Public Museum, Milwaukee. 160 pp., illus. U.S.\$14.95.

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†**Rhinos: endangered species.** 1988. By Malcolm Penny. Facts on File, New York. 116 pp., illus. + plates. U.S.\$19.95 (\$26.95 in Canada).

†**Rocky Mountain mammals: a handbook of mammals of Rocky Mountain National Park and vicinity.** 1987. By David M. Armstrong. Colorado Associated University Press, Boulder. 223 pp., illus. Cloth U.S.\$16.95; paper U.S.\$8.95.

†**Running with the fox.** 1988. By David Macdonald. Facts on File, New York. 224 pp., illus. U.S.\$23.95.

***Sea snakes.** 1987. By Harold Heatwole. New South Wales University Press, Kensington. viii + 85 pp., illus. A\$12.95.

†**The skuas.** 1987. By Robert W. Furness. Buteo Books, Vermillion, South Dakota. 363 pp., illus. U.S.\$45.

***A synopsis of the avifauna of China.** 1987. By Cheng Tso-hsin. Paul Parey Scientific Publishers, New York. xvi + 1222 pp., illus. U.S.\$163.

Tigers of the world: the biology, biopolitics, management and conservation of an endangered species. 1987. Edited by Ronald L. Tilson and Ulysses S. Seal. Noyes Data Corporation, Park Ridge, New Jersey. 510 pp., illus. U.S.\$64.

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***Waterfowl: an identification guide to the ducks, geese, and swans of the world.** 1988. By Steve Madge. Houghton Mifflin (distributed by Thomas Allen, Markham, Ontario). 298 pp., illus. \$55.

Water pollution and fish physiology. 1987. By Alan G. Heath. CRC Press, Boca Raton, Florida. 272 pp. U.S.\$145 in U.S.A.; U.S.\$165 elsewhere.

***Whitetail country: a photographically illustrated life history of the white-tailed deer.** 1988. By Daniel J. Cox and John Ozoga. Willow Creek Press, Wautoma, Wisconsin. xi + 145 pp., illus. U.S.\$39 plus U.S.\$2 shipping.

***Wild furbearer management and conservation in North America.** 1987. Edited by Milan Novak, James A. Baker, Martyn E. Obbard, and Bruce Malloch. Ontario Ministry of Natural Resources and Ontario Trappers Association, Toronto and North Bay. xviii + 1150 pp., illus. \$75 plus \$4 postage.

†**Wildlife areas of special interest to the Department of Renewable Resources.** 1987. By R. S. Ferguson. Northwest Territories Department of Culture and Communication, Yellowknife. 207 pp + map. Free.

Wildlife in America. 1987. By Peter Matthiessen. Second edition. Sifton (Viking Penguin, New York). 332 pp., illus. + plates. U.S. \$29.95.

Wildlife management and habitats, volume 2. 1987. Edited by F. J. Singer. Proceedings of a conference, Colorado State University, Fort Collins. George Wright Society, Hancock, Michigan. 184 pp. U.S.\$7.50.

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The Acrochaetiaceae (Rhodophyta): an annotated bibliography. 1987. By David F. Garbary. Cramer, Berlin. 267 pp. DM 110.

Atlas and catalogue of the diatom types of Friedrich Hustedt. 1987. By Reimer Simonsen. Cramer, Berlin. Three volumes, x + 1741 pp. + 772 plates. Volume 1, Catalogue U.S.\$107; volumes 2 and 3, atlas U.S.\$496; set U.S.\$555.

The bryophytes of the Palaeozoic and the Mesozoic. 1987. By C. Oostendorp. Cramer, Berlin. 216 pp + plates. DM 120.

Collecting, processing, and germinating seeds of wildland plants. 1986. By James A. Young and Cheryl G. Young. Timber Press, Portland, Oregon. 236 pp. U.S.\$24.95.

Diatoms from Viti Levu, Fiji Islands. 1987. By Niels Foged. Cramer, Berlin. 194 pp + plates. DM 90.

***Encyclopedia of ferns.** 1987. By David L. Jones. Lothian (distributed by Timber Press, Portland, Oregon). xvii + 433 pp., illus. U.S.\$55.95.

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The freshwater algae of the Ukranian SSR, V: subclass Protococcinae, Vacuolales and Protococcales. 1987. By O. A. Korshinkov. Translated by J. W. G. Lund and W. Tylka. Doeltz Scientific Books, Koenigstein, West Germany. 412 pp., illus. DM 148.

Freshwater and marine diatoms from Palawan (a Philippine island). 1987. By Andrew C. Podzorski and Hannelore Hakansson. Cramer, Berlin. 245 pp + plates. DM 120.

†**Illustrated guide to some hornworts, liverworts, and mosses of eastern Canada.** 1987. By Robert R. Ireland and Gilda Bellolio-Trucco. Syllogeus 62, National Museum of Natural Sciences, Ottawa. 205 pp., illus. Free.

Leaf venation patterns, volume 1: Annonaceae and volume 2: Lauraceae. 1986, 1987. By Edward P. Klucking. Cramer, Berlin. 256 pp + plates and 216 pp. + plates. DM 220 and DM 240.

The marine algae and coastal environment of tropical west Africa. 1987. By G. W. Lawson and D. M. John. Second edition. Cramer, Berlin. vi + 416 pp., illus. + plates. DM 220.

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Index to Volume 102

Compiled by W. Harvey Beck

- Aaberg, S. A., 515
Abies balsamea, 217
Acantholumpenus mackayi, 85
Acer rubrum, 8, 634
Achillea millefolium, 33
Acipenser brevirostrum, 82
 fulvescens, 82
 medirostris, 82
 oxyrhynchus, 83
 transmontanus, 83
Acipenser medirostris, Green Sturgeon, in Canada, Status of the, 286
Actinonaias ligamentina carinata, 620
Agabus antennatus, 248
 erichsoni, 248
Age structure analysis of a virgin White Pine, *Pinus strobus*, population, 221
Aiken, S. G., review by, 189
Alaska, 69, 541
Alaska, New distributional records of marine fishes off Washington, British Columbia and, 491
Alaska, Winter and early spring habitat use by Snowshoe Hares, *Lepus americanus*, in south-central, 25
Alaska, Yellow-billed Loon, *Gavia adamsii*, breeding chronology and reproductive success in arctic, 485
Alasmidonta marginata, 620
 viridis, 620
Alberta, 170, 425, 495
Alberta, Breeding of the Rock Dove, *Columba livia*, in January at Edmonton, 76
Alberta: cultural versus natural dispersal, Bitterroot, *Lewisia rediviva*, in southwestern, 515
Alberta grasslands, Viability and germination of herbaceous perennial species native to southern, 31
Alberta, Migratory patterns of the Wapiti, *Cervus elaphus*, in Banff National Park, 12
Alberta, The Wandering Shrew, *Sorex vagrans*, in, 254
Alberta, Two pussy's-toes, *Antennaria alborosea* and *A. stolonifera*: additions to the vascular flora of, 649
Albugo cruciferarum, 447
 lepigoni, 447
Alca torda, 676
Alces alces, Moose, and White-tailed Deer, *Odocoileus virginianus*, of Nova Scotia, Brainworm, *Parelaphostrongylus tenuis*, in, 639
Alces alces, Moose, calf mortality in New Brunswick, 74
Alfred Bog, 269
Alle alle, 676
Allium textile, 33
Allolumpenus hypochromus, 85
Alopex lagopus, 725
 lagopus groenlandicus, 668
Alosa aestivalis, 82
Alosa aestivalis, Blueback Herring, in a coastal stream on Prince Edward Island, Observations on the diel and seasonal drift of eggs and larvae of anadromous Rainbow Smelt, *Osmerus mordax*, and, 508
Amblema plicata, 617
 plicata plicata, 618
Ambystoma laterale, Blue-spotted Salamander, in southwestern Nova Scotia, A disjunct population of the, 263
Amelanchier arborea, 634
Ammocrypta pellucida, 84
Anarhichas orientalis, 85
Anas platyrhynchos, Mallards, Bill morphology in American Black Ducks, *Anas rubripes*, and, 720
Anas rubripes, American Black Ducks, and Mallards, *A. platyrhynchos*, Bill morphology in, 720
Anderson, A. B. Shrubby Evening Primrose, *Calylophus serrulatus*, adventive in Wellington County, Ontario, 737
Anemone cylindrica, 33
 multifida, 33
Anodonta grandis grandis, 617
 imbecillis, 617
Anodontoides ferussacianus, 620
Anser caerulescens, 667
Anser c. caerulescens, Lesser Snow Geese, nesting on Jenny Lind Island, Northwest Territories, 530
Antennaria alborosea and *A. stolonifera*: additions to the vascular flora of Alberta, Two pussy's-toes, 649
Antennaria nitida, 32
Anthracoidea atratae, 458
 bigelowii, 458
 buxbaumii, 458
 capillaris, 458
 elynae var. *elynae*, 458
 heterospora, 458
 karii, 458
 limosa, 458
 paniceae, 459
 rupestris, 459
 scirpi, 459
 scirpoideae, 459
 subinclusa, 459
Apeltes quadracus, Fourspine Stickleback, to Thunder Bay, Lake Superior, Range extension for the, 653
Apiosporina collinsii, 449
Aralia nudicaulis L., Wild Sarsaparilla, The Biological Flora of Canada: 8., 45
Archilochus colubris, 11
Ardea herodias, Great Blue Heron, colony, Quetico Provincial Park, Ontario, Aspects of history and nestling mortality at a, 237
Arenaria interpres, 667

- Armstrong, D. P. Persistent attempts by a male Calliope Hummingbird, *Stellula calliope*, to copulate with newly fledged conspecifics, 259
- Arnica fulgens*, 33
- Ascochyta pisi*, 448
- Asemichthys taylori*, 85
- Aster conspicuus*, Showy Aster, Distribution of the, 523
- Aster, Showy, *Aster conspicuus*, Distribution of the, 523
- Astragalus bisulcatus*, 32
- crassicaarpus*, 32
- drummondii*, 32
- gilviflorus*, 33
- pectinatus*, 32
- striatus*, 32
- Atkinson, J. E., review by, 592
- Atopospora betulina*, 449
- Atylus carinatus*, 243
- Aythya marila*, Greater Scaup, in New Brunswick, Breeding records of the, 718
- Azolla caroliniana*, Mosquito Fern, in Ontario, A second record of the, 545
- Baillie Fund grants, 1988, 80
- Baillie Fund grants available for 1989, 80
- Bain, J. F., 45
- Balaena mysticetus*, 83
- Balaena mysticetus*, Bowhead Whale, sightings off the coast of Manitoba, 538
- Balaenoptera acutorostrata*, 85
- borealis*, 85
- musculus*, 82
- physalus*, 83
- Balaenoptera physalus*, Fin Whale, in Canada, Status of the, 351
- Baldwin, M. E. Updated status of the Silver Shiner, *Notropis photogenis*, in Canada, 147
- Baleine grise, 369
- Banfield, A. W. F., review by, 746
- Barracudina, Duckbill, 492
- Bass, Striped, 83
- Bat, Hoary, *Lasiurus cinereus*, with a discussion of other records of migratory tree bats in Atlantic Canada, First Newfoundland record of the, 726
- Baxter, R. M., review by, 603
- Baydack, R. K. Characteristics of Sharp-tailed Grouse, *Tympanuchus phasianellus*, leks in the parklands of Manitoba, 39
- Bayer, M., 425
- Bear, Brown, *Ursus arctos*, with six young, 541
- Behavior responses and reproduction of Mule Deer, *Odocoileus hemionus*, does following experimental harassment with an all-terrain vehicle, 425
- Behaviour and management of Trumpeter Swans, *Cygnus buccinator*, wintering at Comox, British Columbia, Habitat use, 434
- Bélanger, L., S. Tremblay, and R. Couture. Bill morphology in American Black Ducks, *Anas rubripes*, and Mallards, *A. platyrhynchos*, 720
- Beluga, Beaufort Sea, 82
- Cumberland Sound, 83
- Northern Quebec, 83
- St. Lawrence River, 83
- Berardius bairdii*, 85
- Beringbella rectangulata*, 685
- Berns, V. D., 541
- Besseyia wyomingensis*, 33
- Betula papyrifera*, 11, 634
- spp., 8
- Bigg, M. A. Status of the California Sea Lion, *Zalophus californianus*, in Canada, 307
- Bigg, M. A. Status of the Steller Sea Lion, *Eumetopias jubatus*, in Canada, 315
- Birkhead, T. R., and D. N. Nettleship. Breeding performance of Black-legged Kittiwakes, *Rissa tridactyla*, at a small, expanding colony in Labrador, 20
- Bissonette, J. A., 722
- Bitterroot, *Lewisia rediviva*, in southwestern Alberta: cultural versus natural dispersal, 515
- Blangy, S., 257, 724
- Blarina brevicauda*, 11
- Bloater, 83
- Blokpoel, H., and J. Struger. Cherry depredation by Ring-billed Gulls, *Larus delawarensis*, in the Niagara Peninsula, Ontario, 430
- Blood, D. A., review by, 194
- Bodaly, R. A., J. W. Clayton, and C. C. Lindsey. Status of the Squana Whitefish, *Coregonus* sp., in the Yukon Territory, Canada, 114
- Boer, A. H. Moose, *Alces alces*, calf mortality in New Brunswick, 74
- Bog Lemming, Southern, *Synaptomys cooperi*, new to islands in Lake Michigan, 64
- Bostrichonema polygoni*, 447
- Bowyer, R. T., 671
- Boyd, H., reviews by, 751, 754
- Brainworm, *Parelaphostrongylus tenuis*, in Moose, *Alces alces*, and White-tailed Deer, *Odocoileus virginianus*, of Nova Scotia, 639
- Brant, 667
- Branta bernicla*, 667
- Brazil, J. F., 722
- Breault, A. M., and K. M. Cheng. Surplus killing of Eared Grebes, *Podiceps nigricollis*, by Mink, *Mustela vison*, in central British Columbia, 738
- Breeding biology of Sandhill Cranes, *Grus canadensis*, on Banks Island, Northwest Territories, Arctic adaptations in the, 643
- Breeding birds and small mammals of a conifer clearcut in Nova Scotia. Effects of the herbicide 2,4,5-T on the habitat and abundance of, 6
- Breeding chronology and reproductive success in arctic Alaska, Yellow-billed Loon, *Gavia adamsii*, 485
- Breeding in the White-tailed Deer, *Odocoileus virginianus*, in northern Minnesota, Late, 552
- Breeding Longear Sunfish, *Lepomis megalotis*, The Redfin Shiner, *Notropis umbratilis*, in the Middle Thames River, Ontario, and its association with, 533
- Breeding of the Rock Dove, *Columba livia*, in January at Edmonton, Alberta, 76
- Breeding of Wilson's Phalarope, *Phalaropus tricolor*, confirmed, New Brunswick, 77

- Breeding performance of Black-legged Kittiwakes, *Rissa tridactyla*, at a small, expanding colony in Labrador, 20
- Breeding population of Ring-billed Gulls, *Larus delawarensis*, in Atlantic Canada, Recent increases in the, 627
- Breeding record of the Dunlin, *Calidris alpina*, on Baffin Island, Northwest Territories, First, 257
- Breeding records of the Greater Scaup, *Aythya marila*, in New Brunswick, 718
- Breeding Red-throated Loons, *Gavia stellata*, on the Queen Charlotte Islands, British Columbia, Habitat characteristics and population estimate of, 679
- Breitung, A. J. Distribution of the Showy Aster, *Aster conspicuus*, 523
- Breitung, August Julius, 1913-1987, A tribute to, 572
- Breton, L., 697
- Bridgland, J., review by, 760
- Briskie, J. V., and S. G. Sealy. Nest re-use and egg burial in the Least Flycatcher, *Empidonax minimus*, 729
- Bristlemouth, Tan, 491
- British Columbia, 259, 286, 296, 307, 315, 495, 701
- British Columbia and Alaska, New distributional records of marine fishes off Washington, 491
- British Columbia, Habitat characteristics and population estimate of breeding Red-throated Loons, *Gavia stellata*, on the Queen Charlotte Islands, 679
- British Columbia, Habitat use, behaviour and management of Trumpeter Swans, *Cygnus buccinator*, wintering at Comox, 434
- British Columbia, Southern range extension of the Dusky Rockfish, *Sebastes ciliatus*, in, 251
- British Columbia, Surplus killing of Eared Grebes, *Podiceps nigricollis*, by Mink, *Mustela vison*, in central, 738
- Brodo, F., reviews by, 190, 601, 764
- Brooks, R. J., 734
- Brousseau, C., 87
- Brown, R. G. B. The wing-moult of fulmars and shearwaters (Procellariidae) in Canadian Atlantic waters, 203
- Brownlie, J. A disjunct population of the Blue-spotted Salamander, *Ambystoma laterale*, in southwestern Nova Scotia, 263
- Brunton, D. F. New Honorary Member and the 1987 Ottawa Field-Naturalists' Club awards, 740
- Brunton, D. F., review by, 761
- Buchanan, J. B. Migration and winter populations of Greater Yellowlegs, *Tringa melanoleuca*, in western Washington, 611
- Buffalo, Bigmouth, 84
- Black, 84
- Bunting, Snow, 668, 725
- Bunting, Snow, *Plectrophenax nivalis*, nests by bumblebees, *Bombus polaris*, in the High Arctic, Colonization of, 544
- Buteo lagopus*, 725
- Buttercup, Hornseed, *Ceratocephalus testiculatus*: a new record for the adventive flora of Saskatchewan, 71
- Byers, T., and R. W. Prach. Diet of the Kelp Snailfish, *Liparis tunicatus*, in Jones Sound, Canadian High Arctic, 242
- Calcarius lapponicus*, 668, 725
- Calidris alba*, 668
- alpina*, 725
- bairdii*, 668, 725
- canutus*, 668, 725
- fuscicollis*, 725
- maritima*, 725
- melanotos*, 725
- pusilla*, 725
- Calidris alpina*, Dunlin, on Baffin Island, Northwest Territories, First breeding record of the, 257
- Calliobdella* sp., 685
- vivida*, 685
- Calonectris diomedea*, 203
- Calylophus serrulatus*, Shrubby Evening Primrose, adventive in Wellington County, Ontario, 737
- Campbell, R. R., 158, 163, 337, 351
- Campbell, R. R. Rare and endangered fishes and marine mammals of Canada: COSEWIC Fish and Marine Mammal Subcommittee Status Reports: IV, 81
- Campbell, R. R. Status of the Sea Mink, *Mustela macrodon*, in Canada, 305
- Campbell, R. R., D. B. Yurick, and N. B. Snow. Predation on Narwhals, *Monodon monoceros*, by Killer Whales, *Orcinus orca*, in the eastern Canadian Arctic, 689
- Campostoma anomalum*, 82
- Canis lupus*, 725
- lupus arctos*, 669
- Carduelis hornemanni*, 668
- Carex aggregata*, 500
- assiniboinensis*, 500
- emoryi*, 500
- frankii*, 500
- glaucoidea*, 500
- inops* subsp. *heliophila*, 500
- leavenworthii*, 500
- lupuliformis*, 500
- obtusata*, 500
- retroflexa*, 500
- shortiana*, 500
- X subimpressa*, 500
- X sullivantii*, 500
- Caribou, 725
- Peary, 669
- Catfish, Flathead, 84
- Catostomus catostomus lacustris*, 83
- platyrhynchus*, 84
- sp., 82
- Ceratocephalus testiculatus*, Hornseed Buttercup, a new record for the adventive flora of Saskatchewan, 71
- Cercospora varia*, 447
- Cercyon cinctus*, 248
- marinus*, 248
- variabilis*, 248
- Cerf de Virginie, 697
- Cervus elaphus*, Wapiti, in Banff National Park, Alberta, Migratory patterns of the, 12
- Chabot de profondeur, 126
- Char, Red (Arctic), 84
- Chelydra serpentina*, Snapping Turtle, in central Ontario, egg retention by a, 734
- Chen caerulescens*, 61, 725

- Cheverie, J. C., 508
 Chinnappa, C. C., 649
 Chipmunk, Eastern, *Tamias striatus*, with supplemental food, Demographic changes of the, 661
 Chmielewski, J. G., and C. C. Chinnappa. Two pussy's-toes, *Antennaria alborosea* and *A. stolonifera*: additions to the vascular flora of Alberta, 649
Chrysomya empetri, 451
 ledi var. *groenlandici*, 451
 ledi var. *rhododendri*, 451
 ledicola, 451
 pirolata, 451
 woronini, 451
 Chub, Gravel, 82
 Hornyhead, 83
 Liard Hotspring Lake, 84
 River, 83
 Silver, 82
 Chub, Gravel, *Hybopsis x-punctata*, in Canada, Updated status of the, 158
 Chubsucker, Lake, 84
 Cisco à mâchoires égales, 97
 Cisco à museau court, 92
 Cisco, Bering, 83
 Blackfin, 83
 Deepwater, 83
 Longjaw, 82
 Shortjaw, 82
 Shortnose, 82
 Spring, 84
 Cisco, Shortjaw, *Coregonus zenithicus*, in Canada, Status of the, 97
 Cisco, Shortnose, *Coregonus reighardi*, in Canada, Status of the, 92
 Clamens, A., 257, 724
Clangula hyemalis, 667, 725
 Clark, S. M., review by, 177
Claviceps purpurea, 449
 Clayton, J. W., 114
 Clément, A.-M., 132
Clethrionomys gapperi, 11
Clinostomus elongatus, 82
Clinostomus elongatus, Redside Dace, in Canada, Status of the, 163
 Cloutier, L., 132
 Coad, B. W., review by, 745
 Cody, W. J. Hornseed Buttercup, *Ceratocephalus testiculatus* a new record for the adventive flora of Saskatchewan, 71
 Cody, W. J., reviews by, 187, 406, 407, 602
 Cody, W. J., and F. W. Schueler. A second record of the Mosquito Fern, *Azolla caroliniana*, in Ontario, 545
Coleosporium asterum, 452
 campanulae, 452
 Colgan, P., reviews by, 177, 589, 590, 591, 749, 750
Coluber nutkensis (Reptilia: Serpentes), The identity of, 716
Columba livia, Rock Dove, in January at Edmonton, Alberta, Breeding of the, 76
Colymbetes exaratus, 248
Contopus borealis, 11
 Cook, F. R., Editor's report for volume 101 (1987), 266
 Cook, F. R., and W. E. Godfrey. A Canadian bibliography of Austin L. Rand, 567
 Corégone du squana, 114
Coregonus alpenae, 82
 artedii, 84
 canadensis, 82
 clupeaformis, 84
 clupeaformis spp., 82
 hoyi, 83
 johannae, 83
 kiyi, 83
 laurettae, 83
 nigripinnis, 83
 reighardi, 82
 sp., 82
 zenithicus, 82
Coregonus clupeaformis, Lake Simcoe Whitefish, in Canada, Status of the, 103
Coregonus reighardi, Shortnose Cisco, in Canada, Status of the, 92
Coregonus sp., Squanga Whitefish, in the Yukon Territory, Canada, Status of the, 114
Coregonus zenithicus, Shortjaw Cisco, in Canada, Status of the, 97
Corvus corax, 668, 725
Corvus corax, Common Raven, caching food in snow, 68
Coryphantha vivipara, 32
 COSEWIC Fish and Marine Mammal Subcommittee Status Reports: IV, Rare and endangered fishes and marine mammals of Canada, 81
Cottus aleuticus, 85
 confusus, 82
 ricei, 85
Couesius plumbeus ssp., 84
 Cougar, *Felis concolor*, sightings in Ontario, 419
 Couture, R., 720
 Crane, Sandhill, 667
 Cranes, Sandhill, *Grus canadensis*, on Banks Island, Northwest Territories, Arctic adaptations in the breeding biology of, 643
 Crapet à longues oreilles, 277
 Crapet vert, 270
 Crins, W. J., 500
 Crins, W. J., reviews by, 183, 184
 Crins, W. J., and B. A. Ford. The parasitic dodders (*Cuscuta: Cuscutaceae*) in Ontario, 209
Cronartium ribicola, 452
 Crows, P. R. Reoccupation of Common Loon, *Gavia immer*, territories following removal of the resident pair, 264
 Currah, R. S., 31
Cuscuta campestris, 209
 cephalanthi, 209
 coryli, 209
 epithymum, 209
 gronovii, 209
 polygonorum, 209
Cuscuta: Cuscutaceae, in Ontario, The parasitic dodders, 209
Cyclonaias tuberculata, 620

- Cyclothone pallida*, 491
Cygnus buccinator, Trumpeter Swans, in western Canada, 1985, The status of, 495
Cygnus buccinator, Trumpeter Swans, wintering at Comox, British Columbia, Habitat use, behaviour and management of, 434
Cylindrosporium leptospermum, 448
Cystophora cristata, 82
- Dace, Banff Longnose, 82
 Finescale, 475
 Leopard, 84
 Nooky, 84
 Northern Redbelly, 475
 Redside, 82
 Speckled, 82
 Umatilla, 83
- Dace, Banff Longnose, *Rhinichthys cataractae smithi*, in Canada, Status of the, 170
- Dace, Redside, *Clinostomus elongatus*, in Canada, Status of the, 163
- Dagg, A. I., review by, 604
- Darter, Channel, 85
 Eastern Sand, 84
 Greenside, 83
 Least, 84
 River, 85
 Tessellated, 84
- Dasyatis violacea*, 491
- deWit, L., review by, 753
- Deer, Mule, *Odocoileus hemionus*, along the east front of the Rocky Mountains, Montana, Ecology of the, 227
- Deer, Mule, *Odocoileus hemionus*, does following experimental harassment with an all-terrain vehicle, Behavior responses and reproduction of, 425
- Deer, White-Tailed, 216
- Deer, White-tailed, *Odocoileus virginianus*, by climatic stress during the rut, Suppression of reproduction in Upper Michigan, 550
- Deer, White-tailed, *Odocoileus virginianus*, fecal groups relative to vegetative biomass and quality in Maine, 671
- Deer, White-tailed, *Odocoileus virginianus*, in northern Minnesota, Late breeding in the, 552
- Deer, White-tailed, *Odocoileus virginianus*, of Nova Scotia, Brainworms, *Parelaphostrongylus tenuis*, in Moose, *Alces alces*, and, 639
- Deer, White-tailed, *Odocoileus virginianus*, on Anticosti Island, Québec, Use of a net gun for capturing, 697
- Delphinapterus leucas*, 82
- Delphinus delphis*, 85
- Demographic changes of the Eastern Chipmunk, *Tamias striatus*, with supplemental food, 661
- Dermochelys coriacea*, Leatherback Turtles, in cold water off Newfoundland and Labrador, Atlantic, 1
- Dicrostonyx groenlandicus*, 669
- Diet of the Kelp Snailfish, *Liparis tunicatus*, in Jones Sound, Canadian High Arctic, 242
- Diets in Maine, Effect of lichen and in vitro methodology on digestibility of winter deer, 216
- Diplocarpon earliana*, 450
maculata, 450
- Distribution of the Showy Aster, *Aster conspicuus*, 523
- Distributional records of marine fishes off Washington, British Columbia and Alaska, New, 491
- Dodds, D. G., 639
- Dodecatheon conjugens*, 36
- Doepker, R. V., 550
- Dolphins, Atlantic White-sided, 85
 Bottlenose, 85
 Common, 85
 Northern Right Whale, 85
 Pacific White-sided, 85
 Risso's, 85
 Striped, 85
 White-beaked, 85
- Douglas, S. D., and T. E. Reimchen. Habitat characteristics and population estimate of breeding Red-throated Loons, *Gavia stellata*, on the Queen Charlotte Islands, British Columbia, 679
- Douglas, S. D., and T. E. Reimchen. Reproductive phenology and early survivorship in Red-throated Loons, *Gavia stellata*, 701
- Dove, Rock, *Columba livia*, in January at Edmonton, Alberta, Breeding of the, 76
- Dovekie, 676
- Drepanopeziza ribis*, 450
- Driver, E. A., reviews by, 180, 596
- Ducks, American Black, *Anas rubripes*, and Mallards, *A. platyrhynchos*, Bill morphology in, 720
- Dumont, P., 132
- Dunlin, 725
- Dunlin, *Calidris alpina*, on Baffin Island, Northwest Territories, First breeding record of the, 257
- Dytiscus alaskanus*, 248
- Eagle, Bald, 701
- Ecology of the American Brook Lamprey, *Lampetra appendix*, in the Mashpee River, Cape Cod, Massachusetts, Some aspects of the, 735
- Ecology of the Mule Deer, *Odocoileus hemionus*, along the east front of the Rocky Mountains, Montana, 227
- Editor's report for volume 101 (1987), 266
- Edwards, Y., reviews by, 193, 763
- Eedy, W. Book review editor's report, volume 101, 742
- Eedy, W., review by, 755
- Eelpout, Ghostly, 493
- Eider, King, 667, 725
- Eiders, King, *Somateria spectabilis*, and Snowy Owls, *Nyctea scandiaca*, near Cape Churchill, Manitoba, Nesting of, 60
- Elliptio dilatata*, 620
- Empidonax alnorum*, 11
- Empidonax minimus*, Least Flycatcher, Nest re-use and egg burial in the, 729
- Enhydra lutris*, 83
- Enochrus diffusus*, 246
hamiltoni, 248

- Epaulard, 689
Epioblasma rangiana, 617
 triquetra, 620
Eremophila alpestris, 725
Erimyzon sucetta, 84
Eriogonum flavum, 33
Ermine, 669
Erysiphe cichoracearum, 449
 polygoni, 449
Eschrichtius robustus, 82
Eschrichtius robustus, Gray Whale, Current status of the, 369
Esox americanus americanus, 84
 americanus vermiculatus, 84
 niger, 84
Esturgeon vert, 286
Etchberger, R. C., R. Mazaika, and R. T. Bowyer. White-tailed Deer, *Odocoileus virginianus*, fecal groups relative to biomass and quality in Maine, 671
Etheostoma blennioides, 83
 microperca, 84
 olmstedii, 84
Eubalaena glacialis, 83
Eubalaena glacialis, Right Whale, on the continental shelf of Nova Scotia, Significant aggregations of the endangered, 471
Eumetopias jubatus, 82
Eumetopias jubatus, Steller Sea Lion, in Canada, Status of the, 315
Evans, D. O., J. J. Houston, and G. N. Meredith. Status of the Lake Simcoe Whitefish, *Coregonus clupeaformis*, in Canada, 103
Evernia mesomorpha, 216
Exobasidium canadense, 459
 cassandrae, 459
 karstenii, 459
 oxycocci, 459
 rostrupii, 460
 sundstroemii, 460
 uvae-ursi, 460
 vaccinii, 460
 vaccinii-uliginosi, 460
Exoglossum maxillingua, 84

Falco rusticolus, 667, 725
Falco rusticolus, Gyrfalcons, in the Northwest Territories, A replacement clutch in wild, 62
Felis concolor, Cougar, sightings in Ontario, 419
Fenton, M. B., reviews by, 594, 595
Fern, Mosquito, *Azolla caroliniana*, in Ontario, A second record of the, 545
Finne, J., 536
Flanagan, L. B., and J. F. Bain. The Biological Flora of Canada: 8. *Aralia nudicaulis* L., Wild Sarsaparilla, 45
Flora of Alberta, Two pussy's-toes, *Antennaria alborosea* and *A. stolonifera*: additions to the vascular, 649
Flora of Canada: 8. *Aralia nudicaulis* L., Wild Sarsaparilla, The Biological, 45
Flora of Saskatchewan, Hornseed Buttercup, *Ceratocephalus testiculatus*: a new record for the adventive, 71
Flores-Villela, O. A., 716
Flycatcher, Alder, 9
 Olive-sided, 9
Flycatcher, Least, *Empidonax minimus*, Nest re-use and egg burial in the, 729
Food, Demographic changes of the Eastern Chipmunk, *Tamias striatus*, with supplemental, 661
Food in snow, Common Raven, *Corvus corax*, caching, 68
Fox, Arctic, 668, 725
Franzin, W. G., 475
Fraser, D., review by, 748
Fratercula arctica, 676
Freedman, B., A. M. Poirier, R. Morash, and F. Scott. Effects of the herbicide 2,4,5-T on the habitat and abundance of breeding birds and small mammals of a conifer clearcut in Nova Scotia, 6
Frog-bit, European, *Hydrocharis morsus-ranae*, in Lake Ontario marshes, 261
Fulmar, Northern, 203, 676
Fulmarus glacialis, 203, 676
Fundulus diaphanus, 84
 notatus, 82
Fusconaia flava, 620

Gaillardia aristata, 32
Galbraith, D. A., C. J. Graesser, and R. J. Brooks. Egg retention by a Snapping Turtle, *Chelydra serpentina*, in central Ontario, 734
Gammarus setosus, 243
Gar, Spotted, 82
Gasterosteus sp., 82
 spp., 83
Gaston, A. J. The mystery of the murre: Thick-billed Murres, *Uria lomvia*, in the Great Lakes Region, 1890-1986, 705
Gavia adamsii, Yellow-billed Loon, breeding chronology and reproductive success in arctic Alaska, 485
Gavia adamsii, Yellow-billed Loons, nest successfully near Glaucous Gull, *Larus hyperboreus*, nests, 69
Gavia arctica, 725
 stellata, 666
Gavia immer, Common Loon, territories following removal of the resident pair, Reoccupation of, 264
Gavia stellata, Red-throated Loons, on the Queen Charlotte Islands, British Columbia, Habitat characteristics and population estimate of breeding, 679
Gavia stellata, Red-throated Loons, Reproductive phenology and early survivorship in, 701
Geese, Lesser Snow, *Anser c. caerulescens*, nesting on Jenny Lind Island, Northwest Territories, 530
Geist, V., 425
George, M., 527
Geothlypis trichas, 11
Gerson, H. B. Cougar, *Felis concolor*, sightings in Ontario, 419
Geum allepicum, 33
 triflorum, 32
Gilbertson, M. Restoring the Great Lakes — means and ends, 555
Gilliland, S., 536
Globicephala melaena, 85
Glomerella cingulata, 449

- Glomopsis corni*, 447
Glycyrrhiza lepidota, 32
 Godfrey, W. E., 567
 Godfrey, W. E. A tribute to Austin Loomer Rand, 1905-1982, 564
 Goff, G. P., and J. Lien. Atlantic Leatherback Turtles, *Dermochelys coriacea*, in cold water off Newfoundland and Labrador, 1
 Goldfinch, American, 9
 Goodwin, C. E., reviews by, 399, 756
 Goose, Snow, 61, 667, 725
 Gould, J. A comparison of avian and mammalian faunas at Lake Hazen, Northwest Territories in 1961-62 and 1981-82, 666
 Goward, T., reviews by, 185, 403, 601
 Graesser, C. J., 734
Grampus griseus, 85
 Grand coregoné du lac Simcoe, 103
Graphoderus occidentalis, 247
 Gravelier, 158
 Gray, P. A., reviews by, 744, 763
 Grebes, Eared, *Podiceps nigricollis*, by Mink, *Mustela vison*, in central British Columbia, Surplus killing of, 738
 Gregory, M. J., M. J. Lacki, and P. K. Williams. Demographic changes of the Eastern Chipmunk, *Tamias striatus*, with supplemental food, 661
 Gregory, P. T., review by, 743
Grindelia squarrosa, 32
 Grouse, Sharp-tailed, *Tympanuchus phasianellus*, leks in the parklands of Manitoba, Characteristics of, 39
Grus canadensis, 667
Grus canadensis, Sandhill Crane, on Banks Island, Northwest Territories, Arctic adaptations in the breeding biology of, 643
 Gull, Glaucous, 668
 Herring, 725
 Gull, Glaucous, *Larus hyperboreus*, nests, Yellow-billed Loons, *Gavia adamsii*, nest successfully near, 69
 Gulls, Ring-billed, *Larus delawarensis*, in Atlantic Canada, Recent increases in the breeding population of, 627
 Gulls, Ringbilled, *Larus delawarensis*, in the Niagara Peninsula, Ontario, Cherry depredation by, 430
Gymnoconia peckiana, 452
Gymnosporangium clavariiforme, 452
 clavipes, 452
 cornutum, 452
 nidus-avis, 453
 Gyrfalcon, 667, 725
 Gyrfalcons, *Falco rusticolus*, in the Northwest Territories, A replacement clutch in wild, 62
Gyrinus confinus, 248
 maculiventris, 246
 minutus, 248
 Habitat and abundance of breeding birds and small mammals of a conifer clearcut in Nova Scotia, Effects of the herbicide 2,4,5-T on the, 6
 Habitat characteristics and population estimate of breeding Red-throated Loons, *Gavia stellata*, on the Queen Charlotte Islands, British Columbia, 679
 Habitat use, behaviour and management of Trumpeter Swans, *Cygnus buccinator*, wintering at Comox, British Columbia, 434
 Habitat use by Snowshoe Hare, *Lepus americanus*, in south-central Alaska, Winter and early spring, 25
Haliaeetus leucocephalus, 701
Halichoerus grypus, Grey Seals, on seabirds around Sable Island, Nova Scotia, Apparent predation by, 675
Haliotis kamtschaticana, 83
Haliphys immaculicollis, 248
 sp. *subguttatus* gr., 248
 strigatus, 246
 Hamilton, J. G., 653
 Hammer, U. T., 246
Haplopappus spinulosus, 33
 Harbicht, S. M., W. G. Franzin, and K. W. Stewart. New distributional records for the minnows *Hybognathus hankinsoni*, *Phoxinus eos*, and *P. neogaeus* in Manitoba, 475
 Hare, Arctic, 669
 Hares, Snowshoe, *Lepus americanus*, in south-central Alaska, Winter and early spring habitat use by, 25
 Harms, V. L. A tribute to August Julius Breitling, 1913-1987, 572
 Hartviksen, C., 547
 Hawk, Rough-legged, 725
 Hazard, K. W., 471
Hedysarum alpinum, 32
Helianthus subrhomboides, 35
Helophorus nitiduloides, 248
 orientalis, 247
Hemicarpha micrantha, 500
Hemidactylum scutatum, Four-toed Salamander, in New Brunswick, First record of the, 712
 Heron, Great Blue, *Ardea herodias*, colony, Quetico Provincial Park, Ontario, Aspects of history and nestling mortality at a, 237
 Herring, Blueback, 82
 Lake, 84
 Herring, Blueback, *Alosa aestivalis*, in a coastal stream on Prince Edward Island, Observations on the diel and seasonal drift of eggs and larvae of anadromous Rainbow Smelt, *Osmerus mordax*, and, 508
Heterotheca villosa, 32
Heuchera richardsonii, 32
 Hills, L. V., 515
 Hjertaas, D. G., P. Hjertaas, and W. J. Maher. Colony size and reproductive biology of the Bank Swallow, *Riparia riparia*, in Saskatchewan, 465
 Hjertaas, P., 465
 Hoff, J. G. Some aspects of the ecology of the American Brook Lamprey, *Lampetra appendix*, in the Mashpee River, Cape Cod, Massachusetts, 735
 Holla, T. A., and P. Knowles. Age structure analysis of a virgin White Pine, *Pinus strobus*, population, 221
 Holm, E., and J. G. Hamilton. Range extension for the Four-spine Stickleback, *Apeltes quadracus*, to Thunder Bay, Lake Superior, 653
 Houston, C. S. John Richard on: Deserving of greater recognition, 558
 Houston, C. S., review by, 182
 Houston, Dr. Stuart, awarded degree, 80
 Houston, J. J., 103, 270, 277

- Houston, J. J. Status of the Green Sturgeon, *Acipenser medirostris*, in Canada, 286
- Houston, J. J. Status of the Shortjaw Cisco, *Coregonus zenithicus*, in Canada, 97
- Hudson, R. J., 12
- Hummingbird, Calliope, *Stellula calliope*, to copulate with newly fledged conspecifics, Persistent attempts by a male, 259
- Hummingbird, Ruby-throated, 9
- Hyalopsora aspidiotus*, 453
- Hybognathus argyritis*, 84
- nuchalis regius*, 84
- Hybognathus hankinsoni*, *Phoxinus eos*, and *P. neogaeus* in Manitoba, New distributional records for the minnows, 475
- Hybopsis storeriana*, 82
- x-punctata*, 82
- Hybopsis x-punctata*, Gravel Chub, in Canada, Updated status of the, 158
- Hydrobius fuscipes*, 248
- Hydrocharis morsus-ranae*, European Frog-bit, in Lake Ontario marshes, 261
- Hydroporus fuscipennis*, 248
- superioris*, 248
- Hygrotus canadensis*, 248
- impressopunctatus*, 247
- masculinus*, 248
- patruelis*, 248
- salinarius*, 246
- sayi*, 248
- tumidiventris*, 246
- Hymenoxys richardsonii*, 33
- Hyperoodon ampullatus*, 85
- Ibis, Glossy, *Plegadis falcinellus*, in Canada, First nesting of the, 536
- Ichthyomyzon castaneus*, 84
- fossor*, 84
- Ictiobus cyprinellus*, 84
- niger*, 84
- Ihlsle Pac, H., W. F. Kasworm, L. R. Irby, and R. J. Mackie. Ecology of the Mule Deer, *Odocoileus hemionus*, along the east front of the Rocky Mountains, Montana, 227
- Irby, L. R., 227
- Isariopsis bulbigera*, 447
- Ischyrocerus anguipes*, 242
- Jaeger, Long-tailed, 668, 725
- Parasitic, 725
- Jamieson, G. S., 491
- Jenks, J. A., and D. M. Leslie, Jr. Effect of lichen and in vitro methodology on digestibility of winter deer diets in Maine, 216
- Johanssonia arctica*, 685
- John, R., reviews by, 179, 180, 400, 587, 599, 747
- Johnston, C. E., and J. C. Cheverie. Observations on the diel and seasonal drift of eggs and larvae of anadromous Rainbow Smelt, *Osmerus mordax*, and Blueback Herring, *Alosa aestivalis*, in a coastal stream on Prince Edward Island, 508
- Jumping Mouse, Meadow, 10
- Junco hyemalis*, 11
- Junco, Northern, 9
- Kasworm, W. F., 227
- Kelly-Ward, P. M., 713
- Kerr, K. D., and W. J. Peterson. Late breeding in the White-tailed Deer, *Odocoileus virginianus*, in northern Minnesota, 552
- Kevan, P. G., review by, 598
- Kilham, L. Common Raven, *Corvus corax*, caching food in snow, 68
- Killifish, Banded, 84
- Kittiwake, Black-legged, 676
- Kittiwakes, Black-legged, *Rissa tridactyla*, at a small, expanding colony in Labrador, Breeding performance of, 20
- Kiyi, 83
- Knight, H., review by, 591
- Knot, Red, 668, 725
- Knowles, P., 221
- Kraus, S. D., 471
- Kukal, O., and D. L. Pattie. Colonization of Snow Bunting, *Plectrophenax nivalis*, nests by bumblebees, *Bombus polaris*, in the High Arctic, 544
- Labidesthes sicculus*, 84
- Labrador, 627
- Labrador, Atlantic Leatherback Turtles, *Dermochelys coriacea*, in cold water off Newfoundland and, 1
- Labrador, Breeding performance of Black-legged Kittiwakes, *Rissa tridactyla*, at a small expanding colony in, 20
- Laccobius carri*, 248
- sp., 248
- Laccophilus biguttatus*, 248
- Lacki, M. J., 661
- Lagenorhynchus acutus*, 85
- albirostris*, 85
- obliquidens*, 85
- Lagopus lagopus*, 61, 725
- mutus*, 667, 725
- Lampetra appendix*, American Brook Lamprey, in the Mashpee River, Cape Cod, Massachusetts, Some aspects of the ecology of the, 735
- Lampetra macrostoma*, 82
- Lamprey, American Brook, *Lampetra appendix*, in the Mashpee River, Cape Cod, Massachusetts, Some aspects of the ecology of the, 735
- Lamprey, Chestnut, 84
- Darktail, 83
- Lake, 82
- Northern Brook, 84
- Lamprops fuscata*, 243
- Lampsilis fasciola*, 620
- radiata* f. *luteola*, 620
- radiata siliquoidea*, 620
- ventricosa*, 620
- Lanteigne, J. Status of the Banff Longnose Dace, *Rhinichthys cataractae smithi*, in Canada, 170
- Lark, Horned, 725

- Larus argentatus*, 725
hyperboreus, 668
- Larus delawarensis*, Ring-billed Gulls, in Atlantic Canada, Recent increases in the breeding population of, 627
- Larus delawarensis*, Ring-billed Gulls, in the Niagara Peninsula, Ontario, Cherry depredation by, 430
- Larus hyperboreus*, Glaucous Gull, nests, Yellow-billed Loons, *Gavia adamsii*, nest successfully near, 69
- Lasiurus cinereus*, Hoary Bat, with a discussion of other records of migratory tree bats in Atlantic Canada, First Newfoundland record of the, 726
- Lasmigona complanata*, 617
compressa, 620
costata, 620
- Lemming, Collared, 669
- Lemming, Southern Bog, *Synaptomys cooperi*, new to islands in Lake Michigan, 64
- Lepisosteus oculatus*, 82
- Lepomis auritus*, 84
cyanellus, 82
gulosus, 84
humilis, 83
megalotis, 82
megalotis peltastes, 533
- Lepomis cyanellus*, Green Sunfish, in Canada, Status of the, 270
- Lepomis megalotis*, Longear Sunfish, in Canada, Status of the, 277
- Lepomis megalotis*, Longear Sunfish, The Redfin Shiner, *Notropis umbratilis*, in the Middle Thames River, Ontario, and its association with breeding, 533
- Leptodea fragilis*, 620
- Leptotrochila ranunculi*, 450
- Lepus americanus*, Snowshoe Hares, in south-central Alaska, Winter and early spring habitat use by, 25
- Lepus arcticus*, 669
- Leslie, D. M., Jr., 216
- Lethenteron alaskense*, 83
- Lewisia rediviva*, Bitterroot, in southwestern Alberta: cultural versus natural dispersal, 515
- Liatris punctata*, 32
- Lien, J., 1
- Ligumia recta*, 620
- Lindsey, C. C., 114
- Linum lewisii*, 33
- Liodessus affinis*, 248
- Liparis tunicatus*, Kelp Snailfish, in Jones Sound, Canadian High Arctic, Diet of the, 242
- Lirula nervata*, 450
- Lissodelphis borealis*, 85
- Lock, A. R. Recent increases in the breeding population of Ring-billed Gulls, *Larus delawarensis*, in Atlantic Canada, 627
- Long, C. A., and J. E. Long. Southern Bog Lemming, *Synaptomys cooperi*, new to islands in Lake Michigan, 64
- Long, J. E., 64
- Longspur, Lapland, 668, 725
- Loon, Arctic, 725
 Red-throated, 666
- Loon, Common, *Gavia immer*, territories following removal of the resident pair, Reoccupation of, 264
- Loon, Yellow-billed, *Gavia adamsii*, breeding chronology and reproductive success in arctic Alaska, 485
- Loons, Red-throated, *Gavia stellata*, on the Queen Charlotte Islands, British Columbia, Habitat characteristics and population estimate of breeding, 679
- Loons, Red-throated, *Gavia stellata*, Reproductive phenology and early survivorship in, 701
- Loons, Yellow-billed, *Gavia adamsii*, nest successfully near Glaucous Gull, *Larus hyperboreus*, nests, 69
- Lophodermium arundinaceum*, 450
exaridum, 450
- Lovejoy, D. A., review by, 177
- Lucas, Z., and I. A. McLaren. Apparent predation by Grey Seals, *Halichoerus grypus*, on seabirds around Sable Island, Nova Scotia, 675
- Lumsden, H. G., and D. J. McLachlin. European Frog-bit, *Hydrocharis morsus-ranae*, in Lake Ontario marshes, 261
- Luvar, 492
- Luvarus imperialis*, 491
- MacCracken, J. G., W. D. Steigers, Jr., and P. V. Mayer. Winter and early spring habitat use by Snowshoe Hares, *Lepus americanus*, in south-central Alaska, 25
- Mackie, G. L., and J. M. Topping. Historical changes in the unionid fauna of the Sydenham River watershed and downstream changes in shell morphometrics of three common species, 617
- Mackie, R. J., 227
- Madill, J. New Canadian records of leeches (Annelida: Hirudinea) parasitic on fish, 685
- Madtom, Brindled, 82
 Margined, 84
 Northern, 84
- Maher, W. J., 465
- Maine, Effect of lichen and in vitro methodology on digestibility of winter deer diets in, 216
- Maine, White-tailed Deer, *Odocoileus virginianus*, fecal groups relative to vegetation biomass and quality in, 671
- Makepeace, S., 77, 536, 718
- Malaxis paludosa*, Bog Adder's-mouth Orchid, in northwestern Ontario, New station for, 548
- Mallards, *A. platyrhynchos*, Bill morphology in American Black Ducks, *Anas rubripes*, and, 720
- Malmiana* spp., 685
virida, 685
- Manitoba, 657
- Manitoba, Bowhead Whale, *Balaena mysticetus*, sightings off the coast of, 538
- Manitoba, Characteristics of Sharp-tailed Grouse, *Tympanuchus phasianellus*, leks in the parklands of, 39
- Manitoba, Nesting of King Eiders, *Somateria spectabilis*, and Snowy Owls, *Nyctea scandiaca*, near Cape Churchill, 60
- Manitoba, New distributional records for the minnows *Hybognathus hankinsoni*, *Phoxinus eos*, and *P. neogaeus* in, 475
- Marssonina potentillae*, 448
sennensis, 448

- Martin, J.-L., A. Clamens, and S. Blangy. First breeding record of the Dunlin, *Calidris alpina*, on Baffin Island, Northwest Territories, 257
- Martin, J.-L., A. Clamens, and S. Blangy. Notes on the birds and large mammals of the Upper Blue Goose River Basin, southwestern Baffin Island, Northwest Territories, 724
- Massachusetts, Some aspects of the ecology of the American Brook Lamprey, *Lampetra appendix*, in the Mashpee River, Cape Cod, 735
- Maude, S. H. A new Ontario locality record for the crayfish, *Orconectes rusticus* from West Duffin Creek, Durham Regional Municipality, 66
- Mauder, J. E. First Newfoundland record of the Hoary Bat, *Lasiurus cinereus*, with a discussion of other records of migratory tree bats in Atlantic Canada, 726
- Mayer, P. V., 25
- Mazaika, R., 671
- McAllister, D. E., review by, 401
- McAlpine, D. F., J. Finne, S. Makepeace, S. Gilliland, and M. Phinney. First nesting of the Glossy Ibis, *Plegadis falcinellus*, in Canada, 536
- McAlpine, D. F., M. Phinney, and S. Makepeace. New Brunswick breeding of Wilson's Phalarope, *Phalaropus tricolor*, confirmed, 77
- McAlpine, D. F., S. Makepeace, and M. Phinney. Breeding records of the Greater Scaup, *Aythya marila*, in New Brunswick, 718
- McCormick, K. J., 495
- McCormick, K. J., and B. Poston. Lesser Snow Geese, *Anser c. caerulescens*, nesting on Jenny Lind Island, Northwest Territories, 530
- McCoy, C. J., and O. A. Flores-Villela. The identity of *Coluber nutkensis* (Reptilia: Serpentes), 716
- McGillivray, W. B. Breeding of the Rock Dove, *Columba livia*, in January at Edmonton, Alberta, 76
- McKee, P., 158, 163
- McKelvey, R. W., and N. A. M. Verbeek. Habitat use, behaviour and management of Trumpeter Swans, *Cygnus buccinator*, wintering at Comox, British Columbia, 434
- McKelvey, R. W., K. J. McCormick, and L. J. Shandruk. The status of Trumpeter Swans, *Cygnus buccinator*, in western Canada, 1985, 495
- McLachlin, D. J., 261
- McLaren, I. A., 675
- Megaptera novaeangliae, 83
- Melamphid, Soft, 492
- Melampsora epitea, 453
- Melampsorella caryophyllacearum, 453
- Melospiza lincolni, 11
- melodia, 11
- Méné long, 163
- Méné-miroir, 147
- Mephitis mephitis, Striped Skunks, A surgical procedure for implanting radio transmitters in, 713
- Meredith, G. N., 103
- Meredith, G. N., and J. J. Houston. Status of the Green Sunfish, *Lepomis cyanellus*, in Canada, 270
- Meredith, G. N., and J. J. Houston. Status of the Longear Sunfish, *Lepomis megalotis*, in Canada, 277
- Meredith, G. N., and R. R. Campbell. Status of the Fin Whale, *Balaenoptera physalus*, in Canada, 351
- Merganser, Red-breasted, 725
- Mergus serrator, 725
- Mesoplodon bidens, 83
- carlhubbsi, 85
- densirostris, 85
- mirus, 85
- stejnegeri, 85
- Metopella sp., 243
- Michigan pine-hardwood forest after clear-cutting and burning. Tree density and modes of tree recruitment in a, 634
- Michigan White-tailed Deer, *Odocoileus virginianus*, by climatic stress during the rut, Suppression of reproduction in Upper, 550
- Microsorex hoyi, 11
- Microtus pennsylvanicus, 11
- Middleton, J., reviews by, 187, 759
- Migration and winter populations of Greater Yellowlegs, *Tringa melanoleuca*, in western Washington, 611
- Migratory patterns of the Wapiti, *Cervus elaphus*, in Banff National Park, Alberta, 12
- Mink, *Mustela vison*, in central British Columbia, Surplus killing of Eared Grebes, *Podiceps nigricollis*, by, 738
- Mink, Sea, 83
- Mink, Sea, *Mustela macrodon*, in Canada, Status of the, 304
- Minnesota, Late breeding in the White-tailed Deer, *Odocoileus virginianus*, in northern, 552
- Minnow, Bluntnose, 84
- Brassy, 475
- Cutlips, 84
- Eastern Silvery, 84
- Pugnose, 82
- Western Silvery, 84
- Minytrema melanops, 82
- Mirounga angustirostris, 82
- Mitchell, E., 369
- Momot, W. T., C. Hartviksen, and G. Morgan. A range extension for the crayfish *Orconectes rusticus*: Sibley Provincial Park, northwestern Ontario, 547
- Monarda fistulosa, 33
- Mongeau, J.-R., P. Dumont, L. Cloutier, et A.-M. Clément. Le statut du Suceur cuivré, *Moxostoma hubbsi*, au Canada, 132
- Monodon monoceros, 82
- Monodon monoceros, Narwhal, in Canada, Status of the, 391
- Monodon monoceros, Narwhals, by Killer Whales, *Orcinus orca*, in the eastern Canadian Arctic, Predation on, 689
- Montana, Ecology of the Mule Deer, *Odocoileus hemionus*, along the east front of the Rocky Mountains, 227
- Mooers, B. H. M., review by, 600
- Moose, *Alces alces*, and White-tailed Deer, *Odocoileus virginianus*, of Nova Scotia, Brainworm, *Parella-phostrongylus tenuis*, in, 639
- Moose, *Alces alces*, calf mortality in New Brunswick, 74
- Morash, R., 6
- Morgan, G., 547

- Morgantini, L. E., and R. J. Hudson. Migratory patterns of the Wapiti, *Cervus elaphus*, in Banff National Park, Alberta, 12
- Morone saxatilis*, 83
- Morphology, Bill, in American Black Ducks, *Anas rubripes*, and Mallards, *A. platyrhynchos*, 720
- Morris, M. M. J., review by, 767
- Morse, 337
- Mortality at a Great Blue Heron, *Ardea herodias*, colony, Quetico Provincial Park, Ontario, Aspects of history and nestling, 237
- Morton, J. K. Hedge Woundwort, *Stachys sylvatica* (Labiatae) in Canada, 539
- Moser, T. J., and D. H. Rusch. Nesting of King Eiders, *Somateria spectabilis*, and Snowy Owls, *Nyctea scandiaca*, near Cape Churchill, Manitoba, 60
- Mouse, Deer, 10
- Meadow Jumping, 10
- White-footed, 10
- Mouse, Deer, *Peromyscus maniculatus*, in insular Newfoundland, 722
- Movement from Canada to the United States, Evidence of autumnal Harbour Seal, *Phoca vitulina*, 527
- Moxostoma carinatum*, 82
- duquesnei*, 83
- erythrurum*, 84
- hubbsi*, 82
- Moxostoma carinatum*, River Redhorse, in Canada, Updated status of the, 140
- Moxostoma hubbsi*, Suceur cuivré, au Canada, Le statut du, 132
- Murphy, R. W., review by, 593
- Murre, Common, 676
- Thick-billed, 676
- Murres, Thick-billed, *Uria lomvia*, in the Great Lakes Region, 1890-1986,
- The mystery of the murres:, 705
- Muskox, 669
- Mustela erminea arctica*, 669
- macrodon*, 83
- Mustela macrodon*, Sea Mink, in Canada, Status of the, 304
- Mustela vison*, Mink, in central British Columbia, Surplus killing of Eared Grebes, *Podiceps nigricollis*, by, 738
- Mycosphaerella colorata*, 449
- ribis*, 449
- Myoxocephalus quadricornis*, 85
- thompsoni*, 82
- Myoxocephalus thompsoni*, Deepwater Sculpin, in Canada, Status of the, 126
- Mysis litoralis*, 243
- Myzobdella lagubris*, 686
- Narval, 391
- Narwhal, 82
- Narwhal, *Monodon monoceros*, in Canada, Status of the, 391
- Narwhals, *Monodon monoceros*, by Killer Whales, *Orcinus orca*, in the eastern Canadian Arctic, Predation on, 689
- Naseux de rapides de Banff, 170
- Nest re-use and egg burial in the Least Flycatcher, *Empidonax minimus*, 729
- Nesting of King Eiders, *Somateria spectabilis*, and Snowy Owls, *Nyctea scandiaca*, near Cape Churchill, Manitoba, 60
- Nesting of the Glossy Ibis, *Plegadis falcinellus*, in Canada, First, 536
- Nesting on Jenny Lind Island, Northwest Territories, Lesser Snow Geese, *Anser c. caerulescens*, 530
- Nests by bumblebees, *Bombus polaris*, in the High Arctic, Colonization of Snow Bunting, *Plectrophenax nivalis*, 544
- Nests, Yellow-billed Loons, *Gavia adamsii*, nest successfully near Glaucous Gull, *Larus hyperboreus*, 69
- Nettleship, D. N., 20
- New Brunswick, 527, 536, 627, 726
- New Brunswick breeding of Wilson's Phalarope, *Phalaropus tricolor*, confirmed, 77
- New Brunswick, Breeding records of the Greater Scaup, *Aythya marila*, in, 718
- New Brunswick, First record of the Four-toed Salamander, *Hemidactylium scutatum*, in, 712
- New Brunswick, Moose, *Alces alces*, calf mortality in, 74
- New Hampshire, 68
- Newfoundland, 627
- Newfoundland and Labrador, Atlantic Leatherback Turtles, *Dermochelys coriacea*, in cold water off, 1
- Newfoundland based on specimens from Gros Morne National Park, Parasitic fungi of, 442
- Newfoundland, Deer Mouse, *Peromyscus maniculatus*, in insular, 722
- Newfoundland record of the Hoary Bat, *Lasiurus cinereus*, with a discussion of other records of migratory tree bats in Atlantic Canada, First, 726
- Nioides* sp? *punctatus*, 248
- Nocomis biguttatus*, 83
- micropogon*, 83
- Noltie, D. B., and R. J. F. Smith. The Redfin Shiner, *Notropis umbratilis*, in the Middle Thames River, Ontario, and its association with breeding Longear Sunfish, *Lepomis megalotis*, 533
- North Carolina, 731
- North, M. R., and M. R. Ryan. Yellow-billed Loon, *Gavia adamsii*, breeding chronology and reproductive success in arctic Alaska, 485
- North, M. R. , and M. R. Ryan. Yellow-billed Loons, *Gavia adamsii*, nest successfully near Glaucous Gull, *Larus hyperboreus*, nests, 69
- Northwest Territories, 242, 495, 544, 689
- Northwest Territories, A replacement clutch in wild Gyrfalcons, *Falco rusticolus*, in the, 62
- Northwest Territories, Arctic adaptations in the breeding biology of Sandhill Cranes, *Grus canadensis*, on Banks Island, 643
- Northwest Territories, First breeding record of the Dunlin, *Calidris alpina*, on Baffin Island, 257
- Northwest Territories, in 1961-62 and 1981-82, A comparison of avian and mammalian faunas at Lake Hazen, 666

- Northwest Territories, Lesser Snow Geese, *Anser c. caerulescens*, nesting on Jenny Lind Island, 530
- Northwest Territories, Notes on the birds and large mammals of the Upper Blue Goose River Basin, southwestern Baffin Island, 724
- Notostomum cyclostomum*, 686
- Notropis anogenus*, 82
- buchanani*, 84
- chrysocephalus*, 84
- dorsalis*, 82
- emiliae*, 82
- heterodon*, 84
- photogenis*, 82
- rubellus*, 84
- texanus*, 84
- umbratilis*, 83
- Notropis photogenis*, Silver Shiner, in Canada, Updated status of the, 147
- Notropis texanus*, Weed Shiner, in Canada, First collections of the, 657
- Notropis umbratilis*, Redfin Shiner, in the Middle Thames River, Ontario, and its association with breeding Longear Sunfish, *Lepomis megalotis*, The, 533
- Noturus insignis*, 84
- miurus*, 82
- stigmatos*, 84
- Nova Scotia, 726
- Nova Scotia, A disjunct population of the Blue-spotted Salamander, *Ambystoma laterale*, in southwestern, 263
- Nova Scotia, Apparent predation by Grey Seals, *Halichoerus grypus*, on seabirds around Sable Island, 675
- Nova Scotia, Brainworm, *Parelaphostrongylus tenuis*, in Moose, *Alces alces*, and White-tailed Deer, *Odocoileus virginianus*, of, 639
- Nova Scotia, Effects of the herbicide 2, 4, 5-T on the habitat and abundance of breeding birds and small mammals of a conifer clearcut in, 6
- Nova Scotia, Significant aggregations of the endangered Right Whale, *Eubalaena glacialis*, on the continental shelf of, 471
- Nyctea scandiaca*, 668
- Nyctea scandiaca*, Snowy Owls, near Cape Churchill, Manitoba, Nesting of King Eiders, *Somateria spectabilis*, and, 60
- Nyssopsora clavellosa*, 453
- Obliquaria reflexa*, 620
- Obovaria olivaria*, 620
- subrotunda*, 620
- Occella impi*, 85
- Oceanobdella pallida*, 685
- sexoculata*, 686
- Oceanodroma leucorhoa*, 676
- Ochthebius kaszabi*, 248
- Odobenus rosmarus rosmarus*, 82
- Odobenus rosmarus rosmarus*, Atlantic Walrus, in Canada, Status of the, 337
- Odocoileus hemionus*, Mule Deer, along the east front of the Rocky Mountains, Montana, Ecology of the, 227
- Odocoileus hemionus*, Mule Deer, does following experimental harassment with an all-terrain vehicle, Behavior responses and reproduction of, 425
- Odocoileus virginianus*, 216
- Odocoileus virginianus*, White-tailed Deer, by climatic stress during the rut, Suppression of reproduction in Upper Michigan, 550
- Odocoileus virginianus*, White-tailed Deer, fecal groups relative to vegetation biomass and quality in Maine, 671
- Odocoileus virginianus*, White-tailed Deer, in northern Minnesota, Late breeding in the, 552
- Odocoileus virginianus*, Whitetailed Deer, of Nova Scotia, Brainworm, *Parelaphostrongylus tenuis*, in Moose, *Alces alces*, and, 639
- Odocoileus virginianus*, White-tailed Deer, on Anticosti Island, Québec, Use of a net gun for capturing, 697
- Ohio, 661
- Oldham, M. J., and W. J. Crins. New and significant records of Ontario sedges (Cyperaceae), 500
- Oldsquaw, 667, 725
- Omble de fontaine aurora, 87
- Onisimus glacialis*, 243
- littoralis*, 243
- Ontario, 87, 104, 140, 147, 158, 163, 262, 264, 270, 277, 539, 617, 713
- Ontario, A range extension for the crayfish *Orconectes rusticus*: Sibley Provincial Park, northwestern, 547
- Ontario, A second record of the Mosquito Fern, *Azolla caroliniana*, in, 545
- Ontario, and its association with breeding Longear Sunfish, *Lepomis megalotis*, The Redfin Shiner, *Notropis umbratilis*, in the Middle Thames River, 533
- Ontario, Aspects of history and nestling mortality at a Great Blue Heron, *Ardea herodias*, colony, Quetico Provincial Park, 237
- Ontario, Cherry depredation by Ring-billed Gulls, *Larus delawarensis*, in the Niagara Peninsula, 430
- Ontario, Cougar, *Felis concolor*, sightings in, 419
- Ontario, Egg retention by a Snapping Turtle, *Chelydra serpentina*, in central, 734
- Ontario locality record for the crayfish *Orconectes rusticus* from West Duffin Creek, Durham Regional Municipality, 66
- Ontario, New station for *Malaxis paludosa*, Bog Adder's-mouth Orchid, in northwestern, 548
- Ontario sedges (Cyperaceae), New and significant records of, 500
- Ontario, Shrubby Evening Primrose, *Calylophus serrulatus*, adventive in Wellington County, 737
- Ontario, The parasitic dodders (*Cuscuta*: Cuscutaceae) in, 209
- Oporornis philadelphia*, 11
- Opuntia polyacantha*, 32
- Orchid, Bog Adder's-mouth, *Malaxis paludosa*, in northwestern Ontario, New station for, 548
- Orcinus orca*, 85

- Orcinus orca*, Killer Whales, in the eastern Canadian Arctic, Predation on Narwhals, *Monodon monoceros*, by, 689
- Orconectes rusticus* from West Duffin Creek, Durham Regional Municipality, A new Ontario locality record for the crayfish, 66
- Orconectes rusticus*: Sibley Provincial Park, northwestern Ontario, A range extension for the crayfish, 547
- Osmerus mordax*, Rainbow Smelt, and Blueback Herring, *Alosa aestivalis*, in a coastal stream on Prince Edward Island, Observations on the diel and seasonal drift of eggs and larvae of anadromous, 508
- Osmerus spectrum*, 83
- Ostreobdella papillata*, 685
- Otarie de Californie, 307
- Ottawa Field-Naturalists' Club awards, Call for nominations for the 1988, 79
- Ottawa Field-Naturalists' Club awards, New Honorary Member and the 1987, 740
- Ottawa Field-Naturalists' Club, Call for nominations for the 1989 Council of The, 79
- Ottawa Field-Naturalists' Club 110th Annual Business Meeting, Notice of The, 79
- Ottawa Field-Naturalists' Club: 12 January 1988, Minutes of the 109th Annual Business Meeting of The, 579
- Otter, Sea, 83
- Ouellet, H. , reviews by, 182, 596, 597
- Ovibos moschatus*, 669
- Owl, Snowy, 668
- Owls, Snowy, *Nyctea scandiaca*, near Cape Churchill, Manitoba, Nesting of King Eiders, *Somateria spectabilis*, and, 60
- Oxytropis monticola*, 32
- sericea*, 32
- Paddlefish, 82
- Paddlefish, *Polyodon spathula*, in Canada, Status of the, 291
- Paralepis atlantica*, 491
- Parelaphostrongylus tenuis*, Brainworm, in Moose, *Alces alces*, and White-tailed Deer, *Odocoileus virginianus*, of Nova Scotia, 639
- Parker, B. J. Status of the Deepwater Sculpin, *Myoxocephalus thompsoni*, in Canada, 126
- Parker, B. J. Status of the Paddlefish, *Polyodon spathula*, in Canada, 291
- Parker, B. J. Status of the Shortnose Cisco, *Coregonus reighardi*, in Canada, 92
- Parker, B. J. Updated status of the River Redhorse, *Moxostoma carinatum*, in Canada, 140
- Parker, B. J., and C. Brousseau. Status of the Aurora Trout, *Salvelinus fontinalis timagamiensis*, a distinct stock endemic to Canada, 87
- Parker, B. J. , P. McKee, and R. R. Campbell. Status of the Redside Dace, *Clinostomus elongatus*, in Canada, 163
- Parker, B. J., P. McKee, and R. R. Campbell. Updated status of the Gravel Chub, *Hybopsis x-punctata*, in Canada, 158
- Parker, C. R. , reviews by, 189, 190, 746, 752
- Parmelee, J. A. Parasitic fungi of Newfoundland based on specimens from Gros Morne National Park, 442
- Pattie, D. L., 544
- Payne, S. M., 237
- Peden, A. E., and G. S. Jamieson. New distributional records of marine fishes off Washington, British Columbia and Alaska, 491
- Penistemon nitidus*, 33
- procerus*, 33
- Percina copelandi*, 85
- shumardi*, 85
- Percymoorensis marmoratis*, 687
- Peromyscus leucopus*, 11
- maniculatus*, 11
- Peromyscus maniculatus*, Deer Mouse, in insular Newfoundland, 722
- Peronospora cakiles*, 447
- parasitica*, 447
- Petalostemon purpureum*, 32
- Peterson, W. J., 552
- Phalarope, Northern, 725
- Red, 725
- Phalarope, Wilson's, *Phalaropus tricolor*, confirmed, New Brunswick breeding of, 77
- Phalaropus fulicarius*, 725
- lobatus*, 725
- Phalaropus tricolor*, Wilson's Phalarope, confirmed, New Brunswick breeding of, 77
- Phenology and early survivorship in Red-throated Loons, *Gavia stellata*, Reproductive, 701
- Philohela minor*, 11
- Phinney, M., 77, 536, 718
- Phleospora aceris*, 448
- Phoca vitulina*, Harbour Seal, movement from Canada to the United States, Evidence of autumnal, 527
- Phocoena phocoena*, 85
- Phocoenoides dalli*, 85
- Phoxinus eos*, and *P. neogaeus* in Manitoba, New distributional records for the minnows *Hybognathus hankinsoni*, 475
- Phoxinus neogaeus* in Manitoba, New distributional records for the minnows *Hybognathus hankinsoni*, *Phoxinus eos*, and, 475
- Phragmidium andersonii*, 453
- rubi-idaei*, 453
- Phyllactinia guttata*, 449
- Phyllostica* ? *fragaricola*, 448
- Physeter catadon*, 85
- Picea* spp., 216
- Pickereel, Chain, 84
- Grass, 84
- Redfin, 84
- Pimephales notatus*, 84
- Pine, White, *Pinus strobus*, population, Age structure analysis of a virgin, 221
- Pinus resinosa*, 635
- strobus*, 634
- Pinus strobus*, White Pine, population, Age structure analysis of a virgin, 221

- Piscicola geometra*, 687
 milneri, 687
 punctata, 687
- Placuntium andromedae*, 450
- Platybdella anarrhichae*, 687
- Plectrophenax nivalis*, 668, 725
- Plectrophenax nivalis*, Snow Bunting, nests by
 bumblebees, *Bombus polaris*, in the High Arctic,
 Colonization of, 544
- Plegadis falcinellus*, Glossy Ibis, in Canada, First nesting
 of the, 536
- Pleurobema sintoxia*, 620
- Plover, American Golden, 725
 Black-bellied, 725
- Pluvialis dominica*, 725
 squatarola, 725
- Poacher, Pixy, 85
 Pricklebreast, 493
 Smootheeye, 493
- Podiceps nigricollis*, Eared Grebes, by Mink, *Mustela*
vison, in central British Columbia, Surplus killing
 of, 738
- Poirier, A. M., 6
- Polyodon spathula*, 82
- Polyodon spathula*, Paddlefish, in Canada, Status of the,
 291
- Pomfret, Rough, 492
- Poole, K. G. A replacement clutch in wild Gyrfalcons,
Falco rusticolus, in the Northwest Territories, 62
- Population, Age structure analysis of a virgin White
 Pine, *Pinus strobus*, 221
- Population estimate of breeding Red-throated Loons,
Gavia stellata, on the Queen Charlotte Islands,
 British Columbia, Habitat characteristics and,
 679
- Population of Ring-billed Gulls, *Larus delawarensis*, in
 Atlantic Canada, Recent increases in the
 breeding, 627
- Population of the Blue-spotted Salamander, *Ambystoma*
laterale, in southwestern Nova Scotia, A
 disjunct, 263
- Populations of Greater Yellowlegs, *Tringa melanoleuca*,
 in western Washington, Migration and winter,
 611
- Populus grandidentata*, 634
 tremuloides, 635
- Porpoise, Dall's, 85
 Harbour, 85
- Poston, B., 530
- Potamilus alatus*, 619
- Potamonectes macronychus*, 248
- Potvin, F., and L. Breton. Use of a net gun for capturing
 White-tailed Deer, *Odocoileus virginianus*, on
 Anticosti Island, Québec, 697
- Prach, R. W., 242
- Predation by Grey Seals, *Halichoerus grypus*, on
 seabirds around Sable Island, Nova Scotia,
 Apparent, 675
- Predation on Narwhals, *Monodon monoceros*, by Killer
 Whales, *Orcinus orca*, in the eastern Canadian
 Arctic, 689
- Prescott, J. H., 471
- Prickleback, Blackline, 85
- Primrose, Shrubby Evening, *Calylophus serrulatus*,
 adventive in Wellington County, Ontario, 737
- Prince Edward Island, 627
- Prince Edward Island, Observations on the diel and
 seasonal drift of eggs and larvae of anadromous
 Rainbow Smelt, *Osmerus mordax*, and Blueback
 Herring, *Alosa aestivalis*, in a coastal stream on,
 508
- Prosopium coulteri*, 83
 cylindraceum, 84
- Prunus pensylvanica*, 634
- Pseudorca crassidens*, 85
- Ptarmigan, Rock, 667, 725
 Willow, 61, 725
- Ptychobranhus fasciolaris*, 620
- Puccinia albulensis* ssp. *albulensis*, 453
 angustata, 453
 bistortae, 453
 calthae, 454
 calthicola, 454
 campanulae, 454
 caricina, 454
 centaureae, 454
 circaeae, 454
 cnic, 454
 bolumbiensis, 454
 coronata, 454
 dioicae, 455
 hieracii, 455
 linkii, 455
 mesomejalis, 455
 orbicula, 455
 poae-nemoralis, 455
 poarum, 455
 porphyrogenita, 456
 punctata var. *punctata*, 456
 punctiformis, 456
 variabilis, 456
 violae, 456
- Pucciniastrum americanum*, 456
 arcticum, 456
 epilobii, 456
 goeppertianum, 457
 potentillae, 457
 pustulatum, 457
 pyrolae, 457
 vaccinii, 457
- Puffin, Atlantic, 676
- Puffinus gravis*, 203, 676
 griseus, 203, 676
 puffinus, 203, 676
- Pyloodictis olivaris*, 84
- Quadrula pustulosa pustulosa*, 620
 quadrula quadrula, 620
- Québec, 132, 140, 277, 720
- Québec, Use of a net gun for capturing White-tailed
 Deer, *Odocoileus virginianus*, on Anticosti
 Island, 697
- Quercus rubra*, 634

- Ramularia destructiva*, 447
heraclei, 447
magnusiana, 447
nemopanthis, 447
vaccinii, 448
- Rand, Austin L., A Canadian bibliography of, 567
- Rand, Austin Loomer, 1905-1982, A tribute to, 564
- Range extension for the crayfish *Orconectes rusticus*: Sibley Provincial Park, northwestern Ontario, A., 547
- Range extension for the Fourspine Stickleback, *Apeltes quadracus*, to Thunder Bay, Lake Superior, 653
- Range extension of the Dusky Rockfish, *Sebastes ciliatus*, in British Columbia, Southern, 251
- Rangifer tarandus*, 725
tarandus pearyi, 669
- Ranunculus testiculatus*, 71
- Raven, Common, 668, 725
- Raven, Common, *Corvus corax*, caching food in snow, 68
- Razorbill, 676
- Redhead, S. A., reviews by, 186, 402, 405, 406, 757
- Redhorse, Black, 83
 Copper, 82, 132
 Golden, 84
 River, 82
- Redhorse, River, *Moxostoma carinatum*, in Canada, Updated status of the, 140
- Redpoll, Hoary, 668
- Reed, J. R. Arctic adaptations in the breeding biology of Sandhill Cranes, *Grus canadensis*, on Banks Island, Northwest Territories, 643
- Reeves, B. O. K., 515
- Reeves, R. R., and E. Mitchell. Current status of the Gray Whale, *Eschrichtius robustus*, 369
- Reimchen, T. E., 679, 701
- Reproduction in Upper Michigan White-tailed Deer, *Odocoileus virginianus*, by climatic stress during the rut, Suppression of, 550
- Reproduction of Mule Deer, *Odocoileus hemionus*, does following experimental harassment with an all-terrain vehicle, Behavior responses and, 425
- Reproductive biology of the Bank Swallow, *Riparia riparia*, in Saskatchewan, Colony size and, 465
- Reproductive phenology and early survivorship in Red-throated Loons, *Gavia stellata*, 701
- Reproductive success in arctic Alaska, Yellow-billed Loon, *Gavia adamsii*, breeding chronology and, 485
- Responses and reproduction of Mule Deer, *Odocoileus hemionus*, does following experimental harassment with an all-terrain vehicle, Behavior, 425
- Rhantus frontalis*, 246
- Rhinichthys cataractae smithi*, 82
catractae ssp., 84
falcatus, 84
osculus, 82
umatilla, 83
- Rhinichthys cataractae smithi*, Banff Longnose Dace, in Canada, Status of the, 170
- Rhytisma prini*, 450
punctatum, 450
salicinum, 451
- Richard, P. R., and R. R. Campbell. Status of the Atlantic Walrus, *Odobenus rosmarus rosmarus*, in Canada, 337
- Richards, L. J., and S. J. Westrheim. Southern range extension of the Dusky Rockfish, *Sebastes ciliatus*, in British Columbia, 251
- Richardson, John: Deserving of greater recognition, 558
- Riparia riparia*, Bank Swallow, in Saskatchewan, Colony size and reproductive biology of the, 465
- Rissa tridactyla*, 676
- Rissa tridactyla*, Black-legged Kittiwakes, at a small, expanding colony in Labrador, Breeding performance of, 20
- Roberts, M. R., 634
- Robin, American, 9
- Rockfish, Dusky, *Sebastes ciliatus*, in British Columbia, Southern range extension of the, 251
- Rorqual commun, 351
- Rosatte, R. C., and P. M. Kelly-Ward. A surgical procedure for implanting radio transmitters in Striped Skunks, *Mephitis mephitis*, 713
- Rosen, M., 712
- Rosenfeld, M., M. George, and J. M. Terhune. Evidence of autumnal Harbours Seal, *Phoca vitulina*, movement from Canada to the United States, 527
- Rubus* spp., 8
strigosus, 11
- Rusch, D. H., 60
- Ryan, M. R., 69, 485
- Salamander, Blue-spotted, *Ambystoma laterale*, in southwestern Nova Scotia, A disjunct population of the, 263
- Salamander, Four-toed, *Hemidactylium scutatum*, in New Brunswick, First record of the, 712
- Salmo salar*, 83
- Salmon, Atlantic, 83
- Salvelinus alpinus* ssp., 84
confluentus, 84
fontinalis timagamiensis, 82
- Salvelinus fontinalis timagamiensis*, Aurora Trout, a distinct stock endemic to Canada, Status of the, 87
- Sanderling, 668
- Sandpiper, Baird's, 668, 725
 Pectoral, 725
 Purple, 725
 Semipalmated, 725
 White-rumped, 725
- Sardine du Pacifique, 296
- Sardine, Pacific, 82
- Sardine, Pacific, *Sardinops sagax*, in Canada, Status of the, 296
- Sardinops sagax*, 82
- Sardinops sagax*, Pacific Sardine, in Canada, Status of the, 296
- Sarsaparilla, Wild, *Aralia nudicaulis* L., The Biological Flora of Canada: 8, 45

- Saskatchewan, 495
 Saskatchewan, Colony size and reproductive biology of the Bank Swallow, *Riparia riparia*, in, 465
 Saskatchewan, Hornseed Buttercup, *Ceratocephalus testiculatus*: a new record for the adventive flora of, 71
 Saskatchewan, Water beetles of some saline lakes in, 246
 Scaup, Greater, *Aythya marila*, in New Brunswick, Breeding records of the, 718
 Scheiner, S. M., T. L. Sharik, M. R. Roberts, and R. Vande Kopple. Tree density and modes of tree recruitment in a Michigan pine-hardwood forest after clear-cutting and burning, 634
 Schueler, F. W., , 545
 Schueler, F. W., reviews by, 758, 762, 765
 Schweigert, J. F. Status of the Pacific Sardine, *Sardinops sagax*, in Canada, 296
Scopelogadus mizolepis bispinosus, 491
 Scott, F., 6
 Sculpin, Cultus Pygmy Coastrange, 85
 Deepwater, 82
 Fourhorn, 85
 Shorthead, 82
 Spinynose, 85
 Spoonhead, 85
 Sculpin, Deepwater, *Myoxocephalus thompsoni*, in Canada, Status of the, 126
 Sea Lion, California, 82
 Steller, 82
 Sea Lion, California, *Zalophus californianus*, in Canada, Status of the, 307
 Sea Lion, Steller, *Eumetopias jubatus*, in Canada, Status of the, 315
 Seal, Harbour, *Phoca vitulina*, movement from Canada to the United States, Evidence of autumnal, 527
 Seal, Hooded, 82
 Northern Elephant, 82
 Seals, Grey, *Halichoerus grypus*, on seabirds around Sable Island, Nova Scotia, Apparent predation by, 675
 Sealy, S. G., 729
Sebastes ciliatus, Dusky Rockfish, in British Columbia, Southern range extension of the, 251
 Sellers, R. A., 541
Senecio canus, 32
Septoria canadensis, 448
 cornicola, 448
 increscens, 448
 ribis, 448
Seriola lalandi dorsalis, 491
 Shandruk, L. J., 495
 Sharik, T. L., 634
 Shearwater, Cory's, 203
 Greater, 203, 676
 Manx, 203, 676
 Sooty, 203, 676
 Shiner, Bigmouth, 82
 Blackchin, 84
 Ghost, 84
 Pugnose, 82
 Redfin, 83
 Rosyface, 84
 Silver, 82
 Striped, 84
 Weed, 84
 Shiner, Redfin, *Notropis umbratilis*, in the Middle Thames River, Ontario, and its association with breeding Longear Sunfish, *Lepomis megalotis*, The, 533
 Shiner, Silver, *Notropis photogenis*, in Canada, Updated status of the, 147
 Shiner, Weed, *Notropis texanus*, in Canada, First collections of the, 657
 Shrew, Arctic, 10
 Masked, 10
 Pygmy, 10
 Short-tailed, 10
 Smoky, 10
 Shrew, Wandering, *Sorex vagrans*, in Alberta, The, 254
 Shrews, Masked, *Sorex cinereus*, An observation of a wild group of, 731
 Silverside, Brook, 84
Simpsonia ambigua, 617
 Skunks, Striped, *Mephitis mephitis*, A surgical procedure for implanting radio transmitters in, 713
 Smelt, Pygmy, 83
 Pygmy Longfin, 84
 Smelt, Rainbow, *Osmerus mordax*, and Blueback Herring, *Alosa aestivalis*, in a coastal stream on Prince Edward Island, Observations on the diel and seasonal drift of eggs and larvae of anadromous, 508
Smilacina stellata, 33
 Smith, H. C. The Wandering Shrew, *Sorex vagrans*, in Alberta, 254
 Smith, R. J. F., 533
 Smreciu, E. A., R. S. Currah, and E. Toop. Viability and germination of herbaceous perennial species native to southern Alberta grasslands, 31
 Snailfish, Kelp, *Liparis tunicatus*, in Jones Sound, Canadian High Arctic, Diet of the, 242
 Snow, N. B., 689
 Solberg, J. W., 541
Solidago rigida, 33
Somateria spectabilis, 667, 725
Somateria spectabilis, King Eiders, and Snowy Owls, *Nyctea scandiaca*, near Cape Churchill, Manitoba, Nesting of, 60
Sorex arcticus, 11
 cinereus, 11
 fumeus, 11
Sorex cinereus, Masked Shrews, An observation of a wild group of, 731
Sorex vagrans, Wandering Shrew, in Alberta, The, 254
 Sparrow, Lincoln's, 9
 Song, 9
 White-throated, 9
 Spatulaire, 291
Sphaerulina taxicola, 450
Spinus tristis, 11
Spirinchus thaleichthys, 84

- Stachys sylvatica*, Hedge Woundwort, (Labiatae) in Canada, 539
- Status of the Atlantic Walrus, *Odobenus rosmarus rosmarus*, in Canada, 337
- Status of the Aurora Trout, *Salvelinus fontinalis timagamiensis*, a distinct stock endemic to Canada, 87
- Status of the Banff Longnose Dace, *Rhinichthys cataractae smithi*, in Canada, 170
- Status of the California Sea Lion, *Zalophus californianus*, in Canada, 307
- Status of the Deepwater Sculpin, *Myoxocephalus thompsoni*, in Canada, 126
- Status of the Fin Whale, *Balaenoptera physalus*, in Canada, 351
- Status of Gravel Chub, *Hybopsis x-punctata*, in Canada, Updated, 158
- Status of the Gray Whale, *Eschrichtius robustus*, Current, 369
- Status of the Green Sturgeon, *Acipenser medirostris*, in Canada, 286
- Status of the Green Sunfish, *Lepomis cyanellus*, in Canada, 270
- Status of the Lake Simcoe Whitefish, *Coregonus clupeaformis*, in Canada, 103
- Status of the Longear Sunfish, *Lepomis megalotis*, in Canada, 277
- Status of the Narwhal, *Monodon monoceros*, in Canada, 391
- Status of the Pacific Sardine, *Sardinops sagax*, in Canada, 296
- Status of the Paddlefish, *Polyodon spathula*, in Canada, 291
- Status of the Redside Dace, *Clinostomus elongatus*, in Canada, 163
- Status of the River Redhorse, *Moxostoma carinatum*, in Canada, Updated, 140
- Status of the Sea Mink, *Mustela macrodon*, in Canada, 304
- Status of the Shortjaw Cisco, *Coregonus zenithicus*, in Canada, 97
- Status of the Shortnose Cisco, *Coregonus reighardi*, in Canada, 92
- Status of the Silver Shiner, *Notropis photogenis*, in Canada, Updated, 147
- Status of the Squanga Whitefish, *Coregonus* sp., in the Yukon Territory, Canada, 114
- Status of the Steller Sea Lion, *Eumetopias jubatus*, in Canada, 315
- Status of Trumpeter Swans, *Cygnus buccinator*, in Western Canada, 1985, The, 495
- Statut du Suceur cuivré, *Moxostoma hubbsi*, au Canada, Le, 132
- Steigers, W. D., Jr., 25
- Stellula calliope*, Calliope Hummingbird, to copulate with newly fledged conspecifics, Persistent attempts by a male, 259
- Stellerina xyosterna*, 491
- Stenella coerulescens*, 85
- Stercorarius longicaudus*, 668, 725
- parasiticus*, 725
- Sterna paradisaea*, 668, 725
- Stewart, K. W., 475
- Stewart, K. W. First collections of the Weed Shiner, *Notropis texanus*, in Canada, 657
- Stickleback, Enos Lake, 83
- Giant, 82
- Texada, 84
- Unarmoured, 82
- Stickleback, Fourspine, *Apeltes quadracus*, to Thunder Bay, Lake Superior, Range extension for the, 653
- Stingray, Pelagic, 491
- Stizostedion vitreum glaucum*, 82
- Stone, G. S., S. D. Kraus, J. H. Prescott, and K. W. Hazard. Significant aggregations of the endangered Right Whale, *Eubalaena glacialis*, on the continental shelf of Nova Scotia, 471
- Stoneroller, Central, 82
- Storm-Petrel, Leach's, 676
- Strong, J. T. Status of the Narwhal, *Monodon monoceros*, in Canada, 391
- Strophitus undulatus undulatus*, 620
- Struger, J., 430
- Sturgeon, Atlantic, 83
- Green, 82
- Lake, 82
- Shortnose, 82
- White, 83
- Sturgeon, Green, *Acipenser medirostris*, in Canada, Status of the, 286
- Suceur ballot, 140
- Suceur cuivré, *Moxostoma hubbsi*, au Canada, Le statut du, 132
- Sucker, Jasper Longnose, 83
- Mountain, 84
- Salish, 82
- Spotted, 82
- Sullivan, J. P., and S. M. Payne. Aspects of history and nesting mortality at a Great Blue Heron, *Ardea herodias*, colony, Quetico Provincial Park, Ontario, 237
- Sunfish, Green, 82
- Longear, 82
- Orangespotted, 83
- Redbreast, 84
- Sunfish, Green, *Lepomis cyanellus*, in Canada, Status of the, 270
- Sunfish, Longear, *Lepomis megalotis*, in Canada, Status of the, 277
- Sunfish, Longear, *Lepomis megalotis*, The Redfin Shiner, *Notropis umbratilis*, in the Middle Thames River, Ontario, and its association with breeding, 533
- Svoboda, J., review by, 408
- Swallow, Bank, *Riparia riparia*, in Saskatchewan, Colony size and reproductive biology of the, 465
- Swans, Trumpeter, *Cygnus buccinator*, in western Canada, 1985, The status of, 495
- Swans, Trumpeter, *Cygnus buccinator*, wintering at Comox, British Columbia, Habitat use, behaviour and management of, 434
- Swordfish, 493

- Synaptomys cooperi*, Southern Bog Lemming, new to islands in Lake Michigan, 64
Synchytrium endobioticum, 446
- Tamias striatus*, Eastern Chipmunk, with supplemental food, Demographic changes of the, 661
Taphrina carnea, 448
robinsoniana, 448
Taractes asper, 491
Taranetzella lyoderma, 491
Taschereau, P., review by, 409
Terhune, J. M., 527
Tern, Arctic, 668, 725
Thermopsis rhombifolia, 32
Thomas, J. E., and D. G. Dodds. Brainworm, *Parella-phostrogylus tenuis*, in Moose, *Alces alces*, and White-tailed Deer, *Odocoileus virginianus*, of Nova Scotia, 639
Thompson, I. D., review by, 588
Thuja occidentalis, 216
Thunnus thynnus, 83
Timms, B. V., and U. T. Hammer. Water beetles of some saline lakes in Saskatchewan, 246
Toop, E., 31
Topminnow, Blackstripe, 82
Topping, J. M., 617
Tremblay, S., 720
Tringa melanoleuca, Greater Yellowlegs, in western Washington, Migration and winter populations of, 611
Trout, Aurora, 82
Bull, 84
Trout, Aurora, *Salvelinus fontinalis timagamiensis*, a distinct stock endemic to Canada, Status of the, 87
Truncilla truncata, 620
Tsuga canadensis, 216
Tucker, B. J., J. A. Bissonette, and J. F. Brazil. Deer Mouse, *Peromyscus maniculatus*, in insular Newfoundland, 722
Tuna, Bluefin, 83
Turdus migratorius, 11
Turnstone, Ruddy, 667
Tursiops truncatus, 85
Turtle, Snapping, *Chelydra serpentina*, in central Ontario, egg retention by a, 734
Turtles, Leatherback, *Dermochelys coriacea*, in cold water off Newfoundland and Labrador, Atlantic, 1
Tympanuchus phasianellus, Sharp-tailed Grouse, leks in the parklands of Manitoba, Characteristics of, 39
- Urban Natural Areas Workshop, held at University of Calgary, 24 January 1987, Proceedings of the, 268
Uredinopsis americana, 457
osmundae, 457
Uria aalge, 676
lomvia, 676
Uria lomvia, Thick-billed Murres, in the Great Lakes Region, 1890-1986, The mystery of the murres:, 705
- Urocystis anemones*, 459
Uromyces armeriae ssp. *hudsonicus*, 457
fallens, 457
polygoni-avicularis, 458
trifolii-repentis, 458
triquetrus, 458
viciae-fabae, 458
Ursus arctos, Brown Bear, with six young, 541
Usnea spp., 216
- Valdensinia heterodoxa*, 451
Vande Kopple, R., 634
Verbeek, N. A. M., 434
Verme, L. J., and R. V. Doecker. Suppression of reproduction in Upper Michigan White-tailed Deer, *Odocoileus virginianus*, by climatic stress during the rut, 550
Villosa fabalis, 617
iris, 620
Vison de mer, 304
Vispo, C. R. An observation of a wild group of Masked Shrews, *Sorex cinereus*, 731
Vole, Meadow, 10
Red-backed, 10
- Waiser, W. A., reviews by, 767
Walleye, Blue, 82
Walrus, Atlantic, 82
Walrus, Atlantic, *Odobenus rosmarus rosmarus*, in Canada, Status of the, 337
Wapiti, *Cervus elaphus*, in Banff National Park, Alberta, Migratory patterns of the, 12
Warbler, Mourning, 9
Warmouth, 84
Warner, B. G., reviews by, 192, 757
Washington, British Columbia and Alaska. New distributional records of marine fishes off, 491
Washington, Migration and winter populations of Greater Yellowlegs, *Tringa melanoleuca*, in western, 611
Watts, P. D. Bowhead Whale, *Balaena mysticetus*, sightings off the coast of Manitoba, 538
Westrheim, S. J., 251
Whale, Baird's Beaked, 85
Blainville's Beaked, 85
Blue, 82
Bowhead, 83
Cuvier's Beaked, 85
False Killer, 85
Fin, 83
Gray, 82
Hubbs' Beaked, 85
Humpback, 83
Killer, 85
Long-finned Pilot, 85
Minke, 85
Northern Bottlenose, 85
Sei, 85
Sowerby's Beaked, 83
Sperm, 85
Stejneger's Beaked, 85
True's Beaked, 85

- Whale, Bowhead, *Balaena mysticetus*, sightings off the coast of Manitoba, 538
- Whale, Fin, *Balaenoptera physalus*, in Canada, Status of the, 351
- Whale, Gray, *Eschrichtius robustus*, Current status of the, 369
- Whale, Right, *Eubalaena glacialis*, on the continental shelf of Nova Scotia, Significant aggregations of the endangered, 471
- Whales, Killer, *Orcinus orca*, in the eastern Canadian Arctic, Predation on Narwhals, *Monodon monoceros*, by, 689
- Whitefish, Acadian, 82
Lake, 84
Lake Simcoe, 82
Mira, 84
Opeongo, 83
Pygmy, 83
Round, 84
Squanga, 82
- Whitefish, Lake Simcoe, *Coregonus clupeaformis*, in Canada, Status of the, 103
- Whitefish, Squanga, *Coregonus* sp., in the Yukon Territory, Canada, Status of the, 114
- Wilk, R. J., J. W. Solberg, V. D. Berns, and R. A. Sellers. Brown Bear, *Ursus arctos*, with six young, 541
- Williams, P. K., 661
- Wilson, M. C., L. V. Hills, B. O. K. Reeves, and S. A. Aaberg. Bitterroot, *Lewisia rediviva*, in southwestern Alberta: cultural versus natural dispersal, 515
- Wisconsin, 64
- Wolf, 725
Arctic, 669
- Wolffish, Bering, 85
- Woodcock, American, 9
- Woodley, S. J., and M. Rosen. First record of the Four-toed Salamander, *Hemidactylum scutatum*, in New Brunswick, 712
- Woundwort, Hedge, *Stachys sylvatica* (Labiatae) in Canada, 539
- Xeneretmus leiops*, 491
- Xiphias gladius*, 491
- Yarmoloy, C., M. Bayer, and V. Geist. Behavior responses and reproduction of Mule Deer, *Odocoileus hemionus*, does following experimental harassment with an all-terrain vehicle, 425
- Yellowlegs, Greater, *Tringa melanoleuca*, in western Washington, Migration and winter populations of, 611
- Yellowtail, 492
- Yellowthroat, Common, 9
- Y-Prickleback, 85
- Yucca glauca*, 33
- Yukon Territory, 495
- Yukon Territory, Canada, Status of the Squanga Whitefish, *Coregonus* sp., in the, 114
- Yurick, D. B., 689

- Zalophus californianus*, 82
- Zalophus californianus*, California Sea Lion, in Canada, Status of the, 307
- Zapus hudsonicus*, 11
- Ziphius cavirostris*, 85
- Zoladeski, C. A. New station for *Malaxis paludosa*, Bog Adder's-mouth Orchid, in northwestern Ontario, 548
- Zonotrichia albicollis*, 11

Index to Book Reviews

Botany

- Catling, P. M., B. Freedman, and Z. Lucas. The Vegetation and Phytogeography of Sable Island, Nova Scotia, 409
- Clapham, A. R., T. G. Tutin, and D. M. Moore. Flora of the British Isles, 407
- Cole, M. M. The Savannas: Biogeography and Geobotany, 600
- Cope, E. A. Native and Cultivated Conifers of Northeastern North America: A Guide, 187
- Galloway, D. J. Flora of New Zealand: Lichens, 601
- Hayward, J. A. New Key to Wild Flowers, 602
- Holmgren, N. H., and B. Angell. Botanical Illustration: Preparation for Publication, 601
- Hurley, J. Mushrooms of the Northeastern Woods: A Visual Guide, 757
- Jenkins, D. T. Amanita of North America, 405
- Kershaw, K. A. Physiological Ecology of Lichens, 403
- Lawrey, J. D. Biology of Lichenized Fungi, 185
- Singer, R. The Agaricales in Modern Taxonomy, 402
- Soper, J. H., and J. M. Powell. Botanical Studies in the Lake Hazen Region, Northern Ellesmere Island, Northwest Territories, Canada, 408
- Steineck, H. Mushrooms in the Garden, 406
- Thiers, H. D. (ed.). The Agaricales (Gilled Fungi) of California, Volumes 1 to 5, 186
- Varga, S. Toronto Islands: Plant Communities and Noteworthy Species, 184
- Welsh, S. L., N. D. Atwood, S. Goodrich, and L. C. Higgins. A Utah Flora, 406
- Whiting, R. E., and P. M. Catling. Orchids of Ontario: An Illustrated Guide, 183

Environment

- Bellamy, D. The Wild Boglands: Bellamy's Ireland, 757
- Camazine, S. The Naturalist's Year: 24 Outdoor Explorations, 763
- Conrader, J. and C., The Northwoods Wildlife Region, 760
- Fradkin, P. L. A River No More: The Colorado River and the West, 603
- Gadd, B. Handbook of the Canadian Rockies: Geology, Plants, Animals, History, and Recreation from Waterton/Glacier to the Yukon, 761
- Garber, S. D. The Urban Naturalist, 604
- Isom, B. G. (ed.). Rationale for Sampling and Interpretation of Ecological Data in the Assessment of Freshwater Ecosystems, 188

- Isom, B. G., S. D. Dennis, and J. M. Bates (eds.). Impact of Acid Rain and Deposition on Aquatic Biological Systems, 190
- Johnson, C. W. Bogs of the Northeast, 190
- Kingsland, S. E. Modeling Nature: Episodes in the History of Population Ecology, 763
- Matthews, G. (photog.) and K. Cumberland (text). Rivers and Lakes in New Zealand, 189
- O'Neill, R. V., D. L. DeAngelis, J. B. Waide, and T. F. H. Allen. A Hierarchical Concept of Ecosystems, 187
- Prescott-Allen, C., and R. Prescott-Allen. The First Resource: Wild Species in the North American Economy, 759
- Vermeij, G. J. Evolution and Escalation An Ecological History of Life, 758
- Wines, R. A. Fertilizer in America From Waste Recycling to Resource Exploitation, 762
- Miscellaneous**
- Baker, R. The American Hunting Myth, 766
- Cairns-Smith, A. G. Seven Clues to the Origin of Life: A Scientific Detective Story, 765
- Chapman, L. J., and D. F. Putnam. The Physiography of Southern Ontario, 192
- Hangay, G., and M. Dingley. Biological Museum Methods Volume 1: Vertebrates, and Volume 2: Plants, Invertebrates, and Techniques, 193
- Legget, R., Rideau Waterway, 764
- Lindsey, A. A. The Bicentennial of John James Audubon, 767
- Miller, E. H. (ed.). Museum Collections: Their Roles and Future in Biological Research, 194
- Saunders, S. R. (ed.). Audubon Reader, The Best Writings of John James Audubon, 767
- Zoology**
- Batulla, B. Butterflies and Moths, 591
- Batulla, B. Insects, Nature Stories for Children, 746
- Brosset, A., et C. Énard. Les oiseaux des régions forestières du nord-est du Gabon, Volume 1: Écologie et comportement des espèces, 182
- Brown, D. E. Arizona Wetlands and Waterfowl, 180
- Brown, J. L. Helping and Communal Breeding in Birds: Ecology and Evolution, 749
- Claridge, E., and E. A. Milligan. Animal Signatures, 588
- Cooperriider, A. Y., R. J. Boyd, and H. R. Stuart (eds.). Inventory and Monitoring of Wildlife Habitat, 744
- Cox, D. J., and J. J. Ozoga. Whitetail Country: The Photographic Life History of Whitetail Deer, 755
- Cramp, S. (ed.). Handbook of Birds of Europe, the Middle East, and North Africa: The Birds of the Western Palearctic, Volume IV: Terns to Woodpeckers, 180
- Doan, K., and R. Osen. Fish, 745
- Edwards, E. P. A Coded Workbook of Birds of the World, Volume 1: Non passerines, and Volume 2: Passerines, 179
- Evans, H. E. Wasp Farm, 598
- Freethy, R. Auks: An Ornithologist's Guide, 747
- Gooders, J., and T. Boyer. Ducks of North America and the Northern Hemisphere, 596
- Grant, P. R. Ecology and Evolution of Darwin's Finches, 751
- Gregg, G., R. Shine, and H. Elmann (eds.) The Biology of Australasian Frogs and Reptiles, 593
- Griffin, D. R. Listening in the Dark: The Acoustic Orientation of Bats and Man, 595
- Hamerstrom, F. Harrier, Hawk of the Marshes: The Hawk that is Ruled by a Mouse, 597
- Harrison, P. Seabirds of the World — A photographic Guide, 587
- Hoage, R. J., and L. Goldman (eds.). Animal Intelligence Insights into the Animal Mind, 589
- Holcik, J. (ed.). The Freshwater Fishes of Europe, Volume 1, Part I: Petromyzontiformes, 401
- Johnsgard, P. A. Diving Birds of North America, 587
- Kastner, J. A. World of Watchers, 182
- Krebs, J. R., and N. B. Davies (eds.). An Introduction to Behavioural Ecology, 590
- Martin, P., and P. Bateson. Measuring Behaviour — An Introductory Guide, 748
- Meldgaard, M. The Greenland Caribou: Zoogeography, Taxonomy, and Population Dynamics, 746
- National Geographic Society. Field Guide to the Birds of North America, 596
- Nethersole-Thompson, D., and M. Waders, Their Breeding, Haunts, and Watchers, 754
- Newton, I. The Sparrowhawk, 753
- Peck, G. K., and R. D. James. Breeding Birds of Ontario Nidology and Distribution, Volume 2: passerines, 756
- Pianca, E. R. Ecology and Natural History of Desert Lizards, 743
- Pratt, H. D., P. L. Bruner, and D. G. Berret. A Field Guide to the Birds of Hawaii and the Tropical Pacific, 400
- Redman, N., and S. Harrap. Birdwatching in Britain: A Site by Site Guide, 599
- Reed, A. (ed.). Eider Ducks in Canada, 592
- Reilly, E. M., and G. Carruth. The Bird Watcher's Diary, 399
- Rubenstein, D. I., and R. W. Wrangham (eds.). Ecological Aspects of Social Evolution in Birds and Mammals, 177
- Scheffer, P. W., and G. B. Wiggins. A Systematic Study of the Nearctic Larvae of the *Hydropsyche morosa* Group (Trichoptera: Hydropsychidae), 752
- Slater, P. J. B. (ed.). The Encyclopedia of Animal Behavior, 591
- Stephens, D. T., and J. R. Krebs. Foraging Theory, 750
- Stokes, D. W., and L. Q. Stokes. A Guide to Animal Tracking and Behavior, 588
- van Zyll de Jong, C. G. Handbook of Canadian Mammals, 2: Bats, 594
- Wrigley, R. E. Mammals in North America, 177

TABLE OF CONTENTS (concluded)

The identity of <i>Coluber nutkensis</i> (Reptilia: Serpentes)	C. J. MCCOY and OSCAR A. FLORES-VILLELA	716
Breeding records of the Greater Scaup, <i>Aythya marila</i> , in New Brunswick	DONALD F. MCALPINE, SCOTT MAKEPEACE, and MARK PHINNEY	718
Bill morphology in American Black Ducks, <i>Anas rubripes</i> , and Mallards, <i>A. platyrhynchos</i>	L. BELANGER, S. TREMBLAY, and R. COUTURE	720
Deer Mouse, <i>Peromyscus maniculatus</i> , in insular Newfoundland	BRIAN J. TUCKER, JOHN A. BISSONETTE, and JOSEPH F. BRAZIL	722
Notes on the birds and large mammals of the upper Blue Goose River Basin, southwestern Baffin Island, Northwest Territories	JEAN-LOUIS MARTIN, ALEX CLAMENS and SYLVIE BLANGY	724
First Newfoundland record of the Hoary Bat, <i>Lasiurus cinereus</i> , with a discussion of other records of migratory tree bats in Atlantic Canada	JOHN E. MAUNDER	726
Nest re-use and egg burial in the Least Flycatcher, <i>Empidonax minimus</i>	JAMES V. BRISKIE and SPENCER G. SEALY	729
An observation of a wild group of Masked Shrews, <i>Sorex cinereus</i>	C. R. VISPO	731
Egg retention by a Snapping Turtle, <i>Chelydra serpentina</i> , in central Ontario	DAVID A. GALBRAITH, CYNTHIA J. GRAESSER, and RONALD J. BROOKS	734
Some aspects of the ecology of the American Brook Lamprey, <i>Lampetra appendix</i> , in the Mashpee River, Cape Cod, Massachusetts	JAMES G. HOFF	735
Shrubby Evening Primrose, <i>Calylophus serrulatus</i> , adventive in Wellington County, Ontario	ALLAN B. ANDERSON	737
Surplus killing of Eared Grebes, <i>Podiceps nigricollis</i> , by Mink, <i>Mustela vison</i> , in central British Columbia	ANDRE M. BREAUULT and KIMBERLY M. CHENG	738
News and Comment		
New Honorary Member and the 1987 Ottawa Field-Naturalists' Club Awards — Book Review		
Editor's Annual Report, Volume 101		740
Book Reviews		
zoology: Ecology and Natural History of Desert Lizards — Inventory and Monitoring of Wildlife Habitat — Fish — Insects, Nature Stories for Children — The Greenland Caribou: Zoogeography, Taxonomy, and Population Dynamics — Auks: An Ornithologist's Guide — Measuring Behaviour: An Introductory Guide — Helping and Communal Breeding in Birds: Ecology and Evolution — Foraging Theory — Ecology and Evolution of Darwin's Finches — A Systematic Study of the Nearctic Larvae of the <i>Hydropsyche morosa</i> Group (Trichoptera: Hydropsychidae) — The Sparrowhawk — Waders, Their Breeding, Haunts, and Watchers — Whitetail Country: The Photographic Life History of Whitetail Deer — Breeding Birds of Ontario: Nidiology and Distribution, Volume 2: Passerines		743
botany: Mushrooms of the Northeastern Woods: A Visual Guide		757
Environment: The Wild Boglands: Bellamy's Ireland — Evolution and Escalation: An Ecological History of Life — The First Resource: Wild Species in the North American Economy — The Northwoods Wildlife Region — Handbook of the Canadian Rockies: Geology, Plants, Animals, History, and Recreation from Waterton/Glacier to the Yukon — Fertilizer in America: From Waste Recycling to Resource Exploitation — Modeling Nature: Episodes in the History of Population Ecology — The Naturalist's Year: 24 Outdoor Explorations		757
Miscellaneous: Rideau Waterway — Seven Clues to the Origin of Life: A Scientific Detective Story — The American Hunting Myth — Audubon Reader, The Best Writings of John James Audubon — The Bicentennial of John James Audubon		764
New Titles		769
Index to Volume 102	Compiled by W. HARVEY BECK	775
Mailing date of the previous issue: 102(3): 30 December 1988		

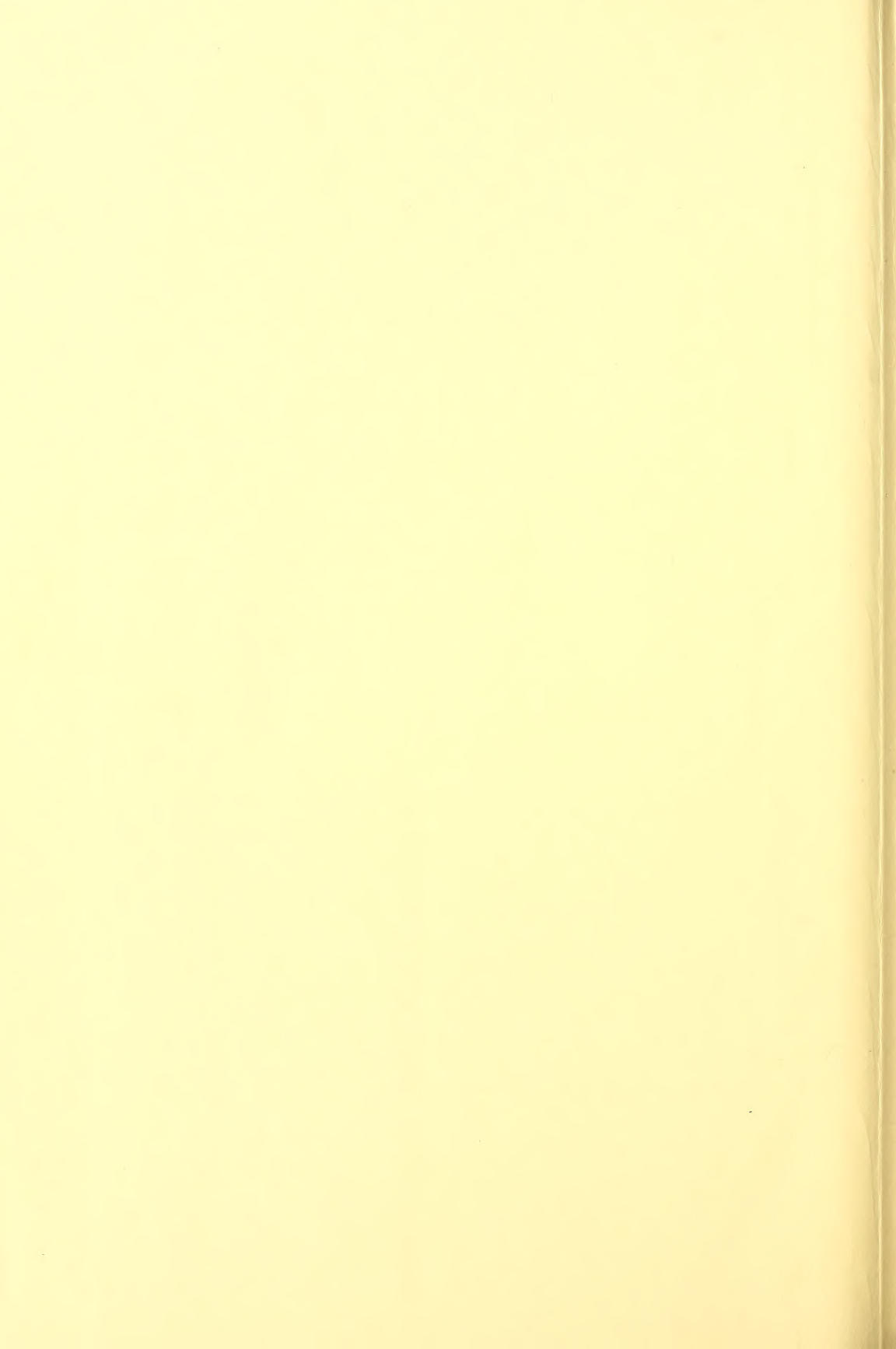
Articles

- Migration and winter populations of Greater Yellowlegs, *Tringa melanoleuca*, in western Washington JOHN B. BUCHANAN 61
- Historical changes in the unionid fauna of the Sydenham River watershed and downstream changes in shell morphometrics of three common species G. L. MACKIE and JANE M. TOPPING 61
- Recent increases in the breeding population of Ring-billed Gulls, *Larus delawarensis*, in Atlantic Canada A. R. LOCK 62
- Tree density and modes of tree recruitment in a Michigan pine-hardwood forest after clear-cutting and burning SAMUEL M. SCHEINER, TERRY L. SHARIK, MARK R. ROBERTS and ROBERT VANDE KOPPLE 63
- Brainworm, *Parelaphostrongylus tenuis*, in Moose, *Alces alces*, and White-tailed Deer, *Odocoileus virginianus*, of Nova Scotia JANIS E. THOMAS and DONALD G. DODDS 63
- Arctic adaptations in the breeding biology of Sandhill Cranes, *Grus canadensis*, on Banks Island, Northwest Territories JOHATHAN R. REED 64
- Two pussy's-toes, *Antennaria alborosea* and *A. stolonifera*; additions to the vascular flora of Alberta J. G. CHMIELEWSKI and C. C. CHINNAPPA 64
- Range extension for the Fourspine Stickleback, *Apeltes quadracus*, to Thunder Bay, Lake Superior ERLING HOLM and JAMES G. HAMILTON 65
- First collections of the Weed Shiner, *Notropis texanus*, in Canada KENNETH W. STEWART 65
- Demographic changes of the Eastern Chipmunk, *Tamias striatus*, with supplemental food MICHAEL J. GREGORY, MICHAEL J. LACKI and P. KELLY WILLIAMS 66
- A comparison of avian and mammalian faunas at Lake Hazen, Northwest Territories, in 1961-62 and 1981-82 JOYCE GOULD 66
- White-tailed Deer, *Odocoileus virginianus*, fecal groups relative to vegetation biomass and quality in Maine RICHARD C. ETCHBERGER, ROSEMARY MAZAIKA and R. TERRY BOWYER 67
- Apparent predation by Grey Seals, *Halichoerus grypus*, on seabirds around Sable Island, Nova Scotia ZOE LUCAS and IAN A. McLAREN 67
- Habitat characteristics and population estimate of breeding Red-throated Loons, *Gavia stellata*, on the Queen Charlotte Islands, British Columbia SHEILA D. DOUGLAS and T. E. REIMCHEN 67
- New Canadian records of leeches (Annelida: Hirudinea) parasitic on fish JACQUELINE MADILL 68
- Predation on Narwhals, *Monodon monoceros*, by Killer Whales, *Orcinus orca*, in the eastern Canadian Arctic R. R. CAMPBELL, D. B. YURICK and N. B. SNOW 68
- Use of a net gun for capturing White-tailed Deer, *Odocoileus virginianus*, on Anticosti Island, Quebec FRANÇOIS POTVIN and LAURIER BRETON 69
- Reproductive phenology and early survivorship in Red-throated Loons, *Gavia stellata* SHEILA D. DOUGLAS and T. E. REIMCHEN 70
- The mystery of the murre: Thick-billed Murres, *Uria lomvia*, in the Great Lakes region, 1890-1986 A. J. GASTON 70

Notes

- First record of the Four-toed Salamander, *Hemidactylium scutatum*, in New Brunswick S. J. WOODLEY and M. ROSEN 71
- A surgical procedure for implanting radio transmitters in Striped Skunks, *Mephitis mephitis* RICHARD C. ROSATTE and PAULA M. KELLY-WARD 71

concluded on inside back cover





3 2044 072 176 183

